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The SCIENTIFIC MONTHLY

VOL. LXV December 1947 NO. 6

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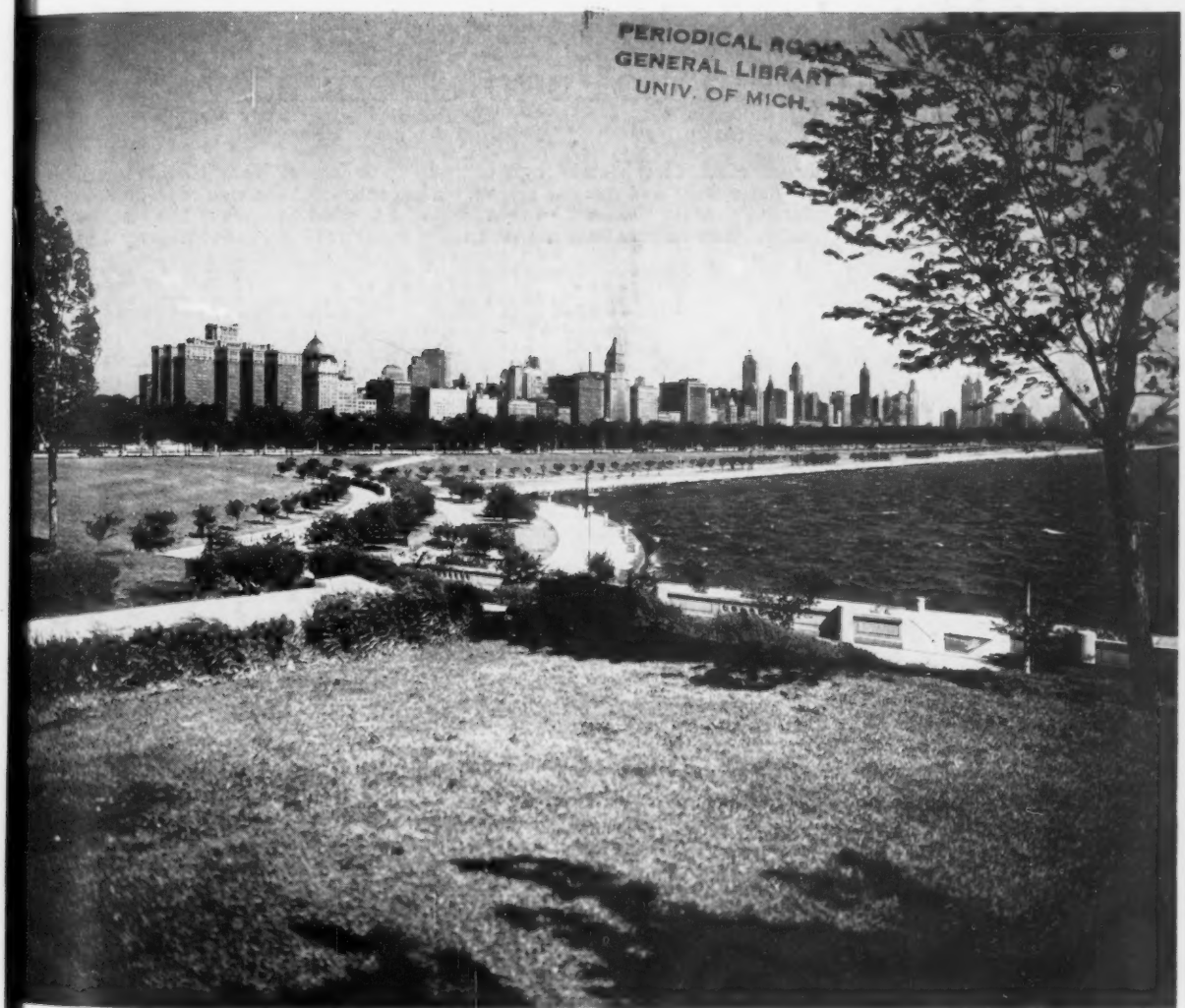

CHICAGO. THE A.A.A.S. MEETS HERE DECEMBER 26-31, 1947.
See Science in Chicago, page 445

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In revising this long-popular text, the authors have brought the earlier edition up to date in many ways. Among new features are the discussion of oxidation reduction in the first chapter so that the concept can be applied throughout the book; additional material on atomic structure and on complex ions; and the focussing of attention throughout the book upon the important basic principle of chemical equilibrium. The theoretical material has been bound separately under the title IONIC EQUILIBRIUM AS APPLIED TO QUALITATIVE ANALYSIS.

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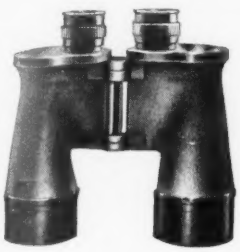

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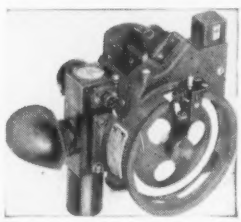

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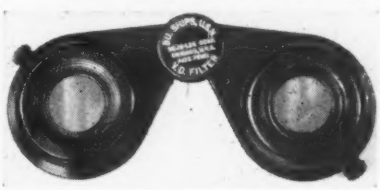

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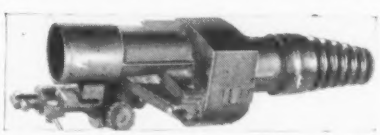

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THE SCIENTIFIC MONTHLY

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Chicago Meeting, A.A.A.S., December 26–31, 1947

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THE SCIENTIFIC MONTHLY

VOL. LXV *December 1947* NO. 6

SCIENCE IN CHICAGO

By JEANNETTE LOWREY *et al.**

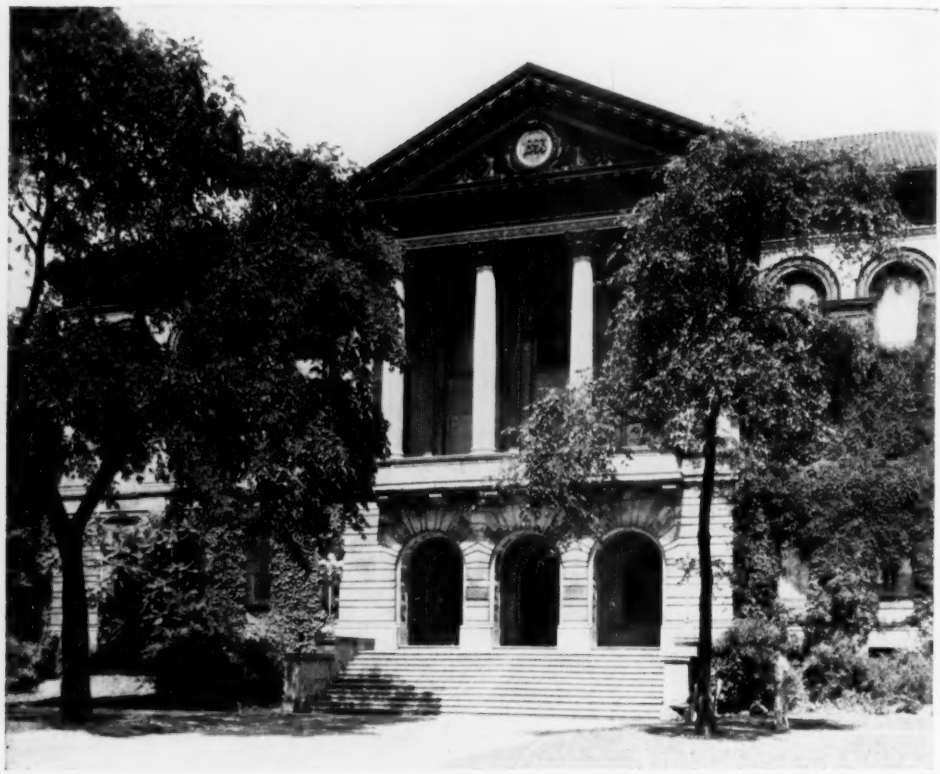
Miss Lowrey, Senior Assistant, Department of Press Relations, The University of Chicago, and Chairman of the Publicity Committee of the Chicago meeting of the A.A.A.S., was requested by the Editor to describe some of the scientific institutions in the Chicago area. Her article and those of her collaborators follow in alphabetical order of the names of the several institutions. Articles about the three new Institutes of The University of Chicago, written by their Directors, are published separately in this issue.

THE CHICAGO ACADEMY OF SCIENCES

THE CHICAGO ACADEMY OF SCIENCES, founded in 1857 for the promotion and diffusion of scientific knowledge, is the oldest scientific organization in Chicago. The founders of the Academy included many of the men who helped to build the city of Chicago: James V. Z. Blaney, Nathan S. Davis, Sr., James W. Freer, Henry Parker, J. Young Scammon, Franklin Scammon, Richard K. Swift, Joseph D. Webster, Eliphalet W. Blatchford, and Henry W. Zimmerman. The first headquarters on the corner of Clark and Lake streets soon were outgrown, and the collections were moved to the Metropolitan Block, where fire seriously damaged them. In 1868 a fireproof museum building was erected at 263 Wabash Avenue. It was unique among museums of the time. The disastrous Chicago fire of 1871, however, completely destroyed this building and the priceless collections it contained. From 1873 until 1892 the collections of the Academy were on display at the Interstate Exposition Building in Grant Park, where the Art Institute now stands. In 1893, through the generosity of Matthew Laflin, the present building was constructed in Lincoln Park at Clark Street and Ogden Avenue. The museum is supported by private endowment, gifts, memberships, and by a share of the museum tax allotment distributed by the Chicago Park District.

The museum presents the natural history of the Chicago region, past and present, and brings to the public other scientific exhibits of current interest. Lifelike habitat groups show the animals in their natural setting along with the herbs, flowers, and trees with which they are usually associated. The scenes range from the lake shore

* Those who collaborated with Miss Lowrey are as follows: Eliot C. Williams, Jr., The Chicago Academy of Sciences; Jean McArthur, Chicago Medical Society; John R. Millar, Chicago Natural History Museum; Lewis M. Glassner, Chicago Technical Societies Council; James W. Armsey, Illinois Institute of Technology; Mary Kay Jones, Mundelein College; Norb Hildebrand, Museum of Science and Industry; Edward Stromberg, Northwestern University; C. Lincoln Williston IV, University of Illinois.



MUSEUM OF NATURAL HISTORY, THE CHICAGO ACADEMY OF SCIENCES

north of Chicago to the Indiana Dunes and show, in addition to the animals that may be found there now, many others that were once residents but that, for one reason or another, are no longer present. The magnificent whooping crane, whose resounding cry once boomed over the marshes surrounding the city; the white-tailed deer, which browsed in the forest that once covered the region; the gulls and terns, which wheel and soar over the bustling traffic of the Michigan Avenue bridge—these are but a few examples of the many animals on exhibition.

The larger vertebrate forms are not the only ones shown in habitat groups. The insects, too, are represented in their natural environment. To mention only a few, one may see hibernating insects, slave-making ants, burying beetles, and a swarm of migratory monarch butterflies.

The habitat groups, because of their nature, cannot include all the animals and plants native to the Chicago region. A systematically arranged series of almost 400 birds, however, gives the bird lover a convenient opportunity to check the identification of any bird he might see. Nests and eggs of some of the more common species of birds are also shown. Representative examples of the hundreds of kinds of insects that may be found in this part of the country and some of their life histories may be seen in the museum.

For those interested in the Chicago area of long ago, there are exhibits of fossil plants and animals. Four large relief maps trace the changes that occurred in Lake Chicago, the large glacial lake that remained after the recession of the last glacier, resulting in our present Lake Michigan. Examples of the rocks and minerals are

available to those interested in the geology of this region.

The Atwood Celestial Sphere, the only one of its kind in the world, is a reproduction of the sky over Chicago. It is a rotating hollow shell of thin sheet metal on which the stars are represented by perforations of different sizes. Within this sphere, unhampered by the light of the sun, moon, or freak illumination, or by inclement weather, it is possible to study the constellations for any season of the year or any hour of the day. The sphere was effectively used for courses in navigation by the Naval Reserve training school at Northwestern University during the war. Elementary and high-school classes also make use of the sphere.

The museum is used by many school classes in their study of natural history. Members of the staff conduct the groups through the museum and present lectures in the auditorium, using the Academy's motion pictures and lantern slides. Several amateur and professional societies are affiliated with the Academy and hold their meetings at the museum. At the present time the affiliated societies are: State Microscopical Society of Illinois, Illinois Audubon Society, Chicago Entomological Society, Marquette Geologists Association, and the Burnham Astronomical Society. The Chicago Herpetologists Club also meets in the Academy building.

Not on public exhibition, but available for the use of qualified students, are the scientific study collections consisting of approximately 14,000 skins of birds and mammals, 10,000 specimens of amphibians and reptiles, 80,000 insects and other invertebrates, and many specimens of rocks, minerals, and fossils.

During the fall and winter months of the year a series of free public lectures is offered on Sunday afternoons in the auditorium of the museum building. The lectures deal with various scientific subjects, travel, explorations, and other aspects of natural history. Many of the lectures are given by well-known authorities in their field and are accompanied by colored slides or motion pictures. Discovering new facts and relating them to human welfare are two important phases of the museum's responsibilities. Although it is not possible for the Academy to give major emphasis to scientific research, members of the staff are endeavoring to do a share of this work commensurate with the amount of time and facilities available.

Serial publications include *The Bulletin of the Chicago Academy of Sciences*, containing technical studies by members of the Academy and the museum staff; *Natural History Miscellanea*, short articles in several fields of natural science; *The Chicago Naturalist*, a nontechnical quarterly; *Studies of the Natural History of the Chicago Area*, devoted to local problems; and *Special Publications*, book-length treatises or others that do not fit into the preceding series.

Field work in the vicinity of Chicago is carried on almost constantly for the purposes of obtaining material for exhibits and adding to the knowledge of the local flora and fauna. When funds are available, expeditions are made to more remote regions in North America for collecting specimens and carrying on scientific studies in natural history. In recent years a number of expeditions have been made to the Southwest, especially the desert regions of Arizona, for the purpose of taking motion pictures and adding to the collections of reptiles, birds, mammals, and invertebrates.

CHICAGO MEDICAL SOCIETY

Chicago Medical Society, organized April 19, 1850, is the largest county medical society in the country, with a membership of approximately 6,300 representing most of the physicians in Cook County. It is divided into 15 branch organizations made up of the physicians in the various sections of the city. There are also 20 affil-

iated societies representing the different specialties of medicine.

The Society is noted for its contributions to the growth and welfare of the city of Chicago, for the part it has played in improving medical education and medical schools in Cook County, and for its education programs, not only for its own members but for other physicians and the general public.

The parent society and each branch organization hold monthly meetings for members. For some years the Society held regular open meetings for the benefit of the citizens of Chicago. During the two years of the Century of Progress International Exposition, the Society scheduled physicians to speak on popular health topics each day in the Hall of Science. Following the opening of the Museum of Science and Industry, the Society has furnished 4 to 8 physicians each year to address public meetings sponsored by the Museum.

Four years ago the Society established the Annual Clinical Conference, an intensive postgraduate course for the general practitioner. Three such meetings have been held, with a large attendance of Midwestern physicians. Hundreds of outstanding medical teachers and scientists have participated in the programs of these conferences.

Plans have been completed for the Society to sponsor short postgraduate courses on medical specialties for doctors of the country. Two of these courses were given in the fall of 1947.

The Society is now working on plans for the publication of a weekly bulletin to be called "This Week in Chicago Medicine." It will inform resident and visiting physicians of current events in the medical schools and hospitals of Chicago.

The Society is represented in many of the civic organizations of Chicago; e.g., Council of Social Agencies, Chamber of Commerce, and Adult Education Council.

CHICAGO NATURAL HISTORY MUSEUM

FOUNDED by a group of civic leaders and endowed by the late Marshall Field as the Field Columbian Museum of Chicago to preserve and develop the mass of natural-history material brought together from all parts of the world by the World's Columbian Exposition of 1893, Chicago Natural History Museum, under the guidance of Mr. Stanley Field, its long-time President, has become in the course of the past fifty-four years, one of Chicago's outstanding institutions, and is now one of the largest natural-history museums in the world.

The fundamental division in museum organization followed by Chicago Natural History Museum provides exhibition collections and reserve (or reference) collections. This is a reflection of a basic duality of interest, in (1) *general education*, which requires a limited number of well-labeled or ingeniously devised exhibits, and in (2) *research*, which requires the vastly greater number of specimens in reference collections. This dichotomy runs through much of the staff of this as of other museums, with scientists and their aids engaged in research and also in the planning of exhibits and supervision of artists and artisans assigned to their preparation. The existence of a research institute in every large museum as a fundamental part of its organization is not well known, even among many groups of scientists. The scientists in this Museum are engaged primarily in description and classification, basic aspects of their respective sciences. That these aspects form the foundations of natural history, and that they have been neglected in America to a disproportionate degree, has become evident in recent decades and is a matter of great concern to Chicago Natural History Museum.

Museums and those universities in which

Photo by Henry Fuermann & Sons

CHICAGO NATURAL HISTORY MUSEUM

UNTIL NOVEMBER 23, 1943, IT WAS KNOWN AS THE FIELD MUSEUM OF NATURAL HISTORY.

museum work still finds appreciation and support especially need to present the possibilities for effective expansion of these types of research. Expansion of exhibition is limited by the walls of the museum building. It should be limited also by another factor—the capacity of the visitor to absorb information, "museum fatigue" being well recognized by psychologists as a special type of tiring of the feet and mind in combination.

Growth of the reference collections may be limited by available space and curatorial staff; but the research activities in the descriptive sciences are capable of very great development. Such expansion of systematic zoology and botany, including especially paleontology, is now essential for the sound growth of the associated sciences. Opportunities for important and interesting research in these directions are endless, and their pursuit is stressed at this Museum.

Department of Anthropology. Underlying the Museum's research in anthropology are its anthropological collections, numbering some 300,000 specimens, and its extensive library of anthropological literature. The collections cover every major area of the world. Particularly outstanding are those in the fields of North American ethnology; archeology of North, Central, and South America; ethnology of Africa, Oceania, and Indonesia; and archeology and ethnology of China. The Melanesian collection is probably the largest and most representative in the world.

During the past ten years scholarly activities in the Department of Anthropology have fallen under four headings: field research, the acquisition of additional collections, the production of scientific reports based on field research and on the study of the Museum's collections, and exhibition work. In spite of the suspension of field work during the war years, nine anthropological expeditions—to Southwestern United

STANLEY FIELD HALL

THE GREAT CENTRAL HALL LEADING TO THE EXHIBITS OF THE CHICAGO NATURAL HISTORY MUSEUM.

States, Ecuador, Peru, and the Marshall Islands—were sent out during the ten-year period.

The recent policy in adding to the anthropological collections has been restrictive and selective. In general, only specimens accompanied by adequate data as to origin and function, which fill serious gaps in the existing collections or are important to the Museum's research program, have been acquired. This policy is appropriate to the needs of a mature museum and to the present status of anthropological research.

Anthropological research in the Museum during the past ten years has been in the fields of North American ethnology, North and South American archeology, ethnology of Oceania and China, anthropology of Africa, archeology and anthropometry of the Near East, and anthropometry of Melanesia. The results of these studies have been published by the Museum and in various scholarly journals.

During the past six years the Department of Anthropology has carried out an extensive exhibition program, directed primarily toward the installation of a new Hall of American Archaeology. The program has involved not only continuous research in new exhibition methods and techniques, but varied anthropological research as a basis for the preparation of the exhibits.

During the war the volume of anthropological research was reduced by the absence of staff members taking part in the war effort. During this period the Department carried out work for the Committee on African Anthropology of the National Research Council. This committee furnished information on Africa and personnel lists to the various war agencies. The Department also cooperated with the Aero Medical Research Laboratory at Wright Field in producing models of physical types used in designing oxygen masks for the Army Air Forces.

Department of Botany. In accordance with the general policy of the Museum, the Department of Botany sponsors two principal fields of activity. One, devoted to public instruction, is concerned with the planning and preparation of exhibits consisting of prepared botanical material and products, supplemented by photographs, paintings, models, and reproductions of plants. The exhibits are displayed in five halls designated, respectively, as Hall of Plant Life, Food Plants, Economic Plants, American Woods, and Foreign Woods.

The other field of activity comprises the acquisition, through botanical expeditions, exchange, and purchase, of botanical collections and their care and scientific study. The phanerogamic herbarium is particularly rich in tropical American material. Similarly, the cryptogamic herbarium is made up of large collections representing all groups of lower plants (algae, fungi, lichens, and mosses), but is especially well known for the extensive representation of fresh-water algae. A special collection of American and Old World palms ranks among the finest of its kind in completeness of the collected material and the aids provided for critical study. A large file of hand samples of woods, representing mostly tropical trees and shrubs, is maintained as a separate reference collection; the accompanying herbarium specimens are incorporated in the phanerogamic herbarium. Special collections of economic plants and plant products are also available for reference and purposes of identification. The combined collections of all kinds total more than a million specimens.

The file of photographs of type and other historically important specimens of American plants, mainly deposited in the great European herbaria, now contains about 40,000 negatives. As many of the priceless original collections were destroyed during World War II, these negatives represent the

AN ANDEAN VALLEY AT THE TIME OF THE INCAS

DIORAMA IN MINIATURE, RECENTLY PLACED ON EXHIBITION IN THE HALL OF NEW WORLD ARCHAEOLOGY AT THE CHICAGO NATURAL HISTORY MUSEUM. IT SHOWS THE TYPICAL TERRACED FARMS, AN IRRIGATION SYSTEM, A SUSPENSION BRIDGE, AND A STONE FORTRESS OF THE EARLY INDIANS OF PERU.

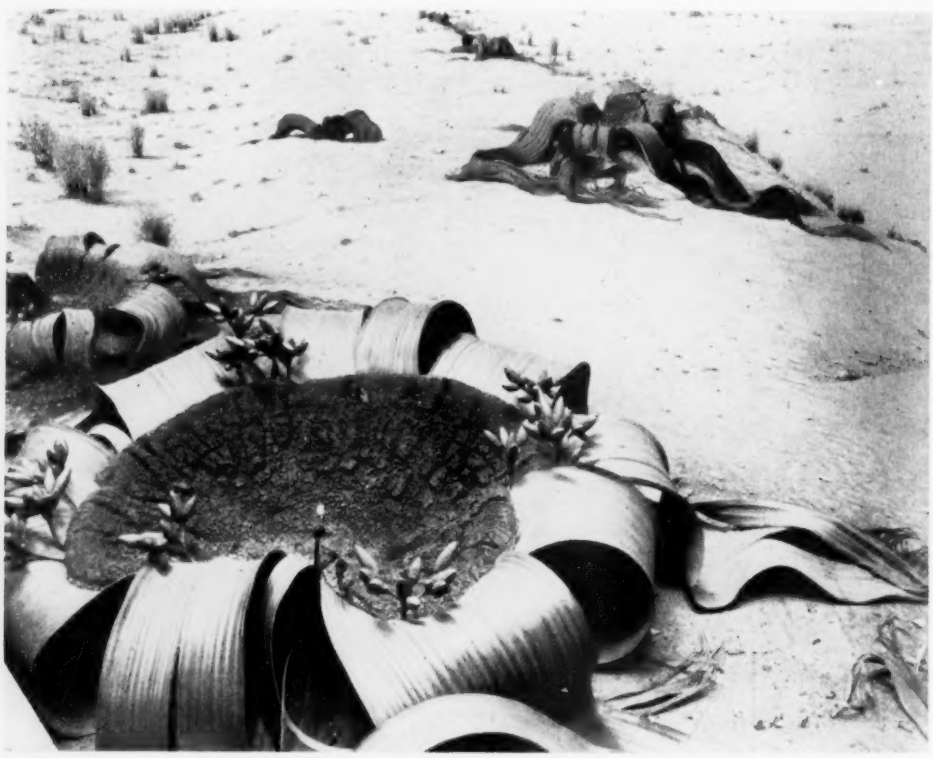
only records in existence. The inestimable value of this collection is generally conceded.

In addition to many special studies and monographs of certain groups, the Department of Botany is engaged in the publication of several large floras, notably the *Flora of Peru*, *Flora of Guatemala*, and the proposed floras of Ecuador and middle Central America.

During the recent war several members of the staff served in various advisory capacities to governmental agencies or were sent abroad by the Board of Economic Warfare.

Department of Geology. The exhibits of the Department of Geology represent most of the fields of this science, the display of vertebrate fossils being especially fine. In this hall, it is the policy to show a limited number of specimens to the best advantage, with a small painting of the restored animal in its natural habitat accompanying each mounted skeleton, and a brief explanatory label in place of the close-printed essay of the older cases. Emphasis in the past has been on displaying as much of the collection as could be crowded into the cabinets. The current program of exhibition involves extensive revision of this material.

The real strength of the Department lies in its reference collections and in the work continually being done with them by members of the staff. Field trips are planned with reference to research needs, and representation in fields of active investigation is continually expanded according to current requirements. In the past few years, important additions have been made in this



WELWITSCHIA PLANTS IN MOSSAMEDES DESERT

NEW HABITAT GROUP IN MARTIN A. AND CARRIE RYERSON HALL AT THE CHICAGO NATURAL HISTORY MUSEUM, SHOWING A RARE AND STRANGE PLANT FOUND ONLY IN SOUTHWEST AFRICA.

A CARBONIFEROUS FOREST OF 250,000,000 YEARS AGO

ONE OF THE FAMOUS EXHIBITS AT THE CHICAGO NATURAL HISTORY MUSEUM.

way in connection with the work being done on arctic Ordovician faunas, turtle classification and evolution, Paleocene mammals, the Mazon Creek flora of the Pennsylvanian, minerals, and metamorphic rocks.

The meteorite collection is unusually fine, more than 70 percent of the known falls being represented. Study of the meteorites is facilitated by a sectioning saw and chemical laboratory on the premises. A revised catalog of the meteorites is now in preparation for publication. In the collection of invertebrate fossils are many of the amazingly well-preserved Mississippian crinoids from now-depleted localities in Indiana and Iowa and a large number of specimens from Patagonia and Newfoundland, collected on past expeditions and still in part unstudied. An X-ray laboratory and a staff of preparators assist the study of the vertebrate fossils, in the collection of which there are many scientifically valuable type specimens of primitive mammals, early birds, turtles, and crocodiles, described by staff members. A cooperative arrangement with The University of Chicago has opened the collection of fossil vertebrates to University classes.

Department of Zoology. The growth of research in systematic zoology in Chicago Natural History Museum is reflected in its

A TYPE SPECIMEN

PHOTOGRAPHS LIKE THIS, MADE FOR THE CHICAGO NATURAL HISTORY MUSEUM BEFORE THE WAR, ARE NOW THE ONLY RECORDS OF TYPES DESTROYED BY BOMBING. THIS SPECIMEN WAS IN BERLIN.

AFRICAN WATER-HOLE GROUP AT THE CHICAGO NATURAL HISTORY MUSEUM

collections and in its publications. These collections have grown from the original nucleus of mounted specimens exhibited by Ward's Natural History Establishment at the World's Columbian Exposition of 1893 in two directions—specimens on exhibition now filling more than 13 halls on the ground floor and first floor of the building; the even greater growth of the research collections has filled available space on the third and fourth floors. The estimated number of objects on exhibition is about 8,000; the estimated number of specimens in the research collections has long since passed the 1,000,000 mark. The scientific staff in zoology alone has grown in fifty years from 4 to 14 members, and the technical papers produced by them compose some 50 volumes. The Museum's zoological collections have pre-eminence in certain special fields, especially those of tropical America and South America generally, but have been kept in the main at a level of world-wide interest and world representation.

CHICAGO TECHNICAL SOCIETIES COUNCIL

SIGNIFICANT of the growing spirit of cooperation among technical men is the Chicago Technical Societies Council, which today, in its fourth year, includes 51 local sections of national scientific, engineering, and technological societies. Local membership of these societies exceeds 18,000.

Under the direction of a full-time staff at 53 West Jackson Boulevard, Chicago, the Council maintains a broad program of activities aimed to further cooperation among the affiliated societies, to provide means for more effective public service by the societies and their members, and to make the community more fully aware of the contributions of these men to community life and betterment.

Executive Secretary of the Council is Paul A. Jenkins, who is also serving as Chairman of the Local Committee on Arrangements for the December 1947 meeting of the A.A.A.S. President of the Council for the 1947–48 year is Dr. Gustav Egloff, Research Director of Universal Oil Products Company.

The Council owes its inception to the war-inspired spirit of close cooperation among all agencies of science, research, engineering, and technology for the purpose of defeating a common enemy. Early in 1943 the War Production Board conceived the idea of sponsoring a series of conferences throughout the United States to provide a means for "swapping" ideas contributed by science, engineering, technology, and management as an aid to war production.

The Chicago War Production Clinic, held on March 11, 1943, at the Medinah Club, was the largest such conference held in the United States.

The local venture was fostered by the War Production Board with the aid of the Chicago Section of the American Society of Mechanical Engineers and 16 other engineering and technical societies of the Chicago area. Following the outstanding success of the 1943 conference, an organizing committee was formed to prepare a prospectus with the purpose of establishing a permanent Chicago Council. On September 2, 1943, the first official meeting of the Chicago Technical Societies Council was held, with 37 representatives of 23 societies in attendance. Officers and directors were elected at this meeting, and the chairmen of 11 committees were appointed.

The Charter Roster of affiliated societies closed at 33 members in November 1943. The Council was formally incorporated under the General Not for Profit Act on February 28, 1944. Under the financing plans of the Council, it was stated that there would be no charges or fees to constituents of the Council and that none of its participants were to receive salaries. Income was to be derived from the following sources: publication of *Sci-En-Tech News*, the monthly bulletin of the Council; periodic publication of a directory of scientific, technical, engineering, and research men and facilities in the Chicago area; and Council-sponsored conferences and exhibits. There were to be no dues or assessments.

With its financial plans formulated and its organizational structure completed, the Council set forth to increase its membership and to fulfill its primary purposes of promoting Chicago as the leading scientific and technological center of the world, and of stimulating production and employment in the city and its surrounding area.

In early 1947 the membership had increased to include 51 societies, with a Council membership of 18,000 engineers, scientists, and technologists. Member-societies represent many fields of activity and include, for example, The Society for Experimental Biology and Medicine, the American Chemical Society, the Western Society of Engineers, The American Institute of Architects, The Industrial Management Society, the Institute of Radio Engineers, The American Society of Mechanical Engineers, the American Pharmaceutical Association, The Instrument Society of America, and the Society of Plastic Engineers.

An annual high light of the Council's activities is the Chicago Production Conference and Show, which, in March 1947 at the Stevens Hotel, was attended by more than 27,000 people. The 1947 Conference presented 86 speakers contributing to 35 panel sessions held during the three-day clinic. In addition, exhibits by 130 suppliers of tools, materials, equipment, and services were displayed for the benefit of executives interested in the broad trends of production techniques and in the industrial development of the Chicago area.

Slightly overshadowed by the annual Production Show and Conference are the many other activities engaged in by the Council and incorporated in its aims and purposes. A representative of the Council sits on the Mayor's Commission for School Board Nominations, which supplies the Mayor with names of citizens to fill vacancies on the School Board. The Council supplies vocational-guidance panels to technical high schools for the benefit of young men who are going on to advanced training in the sciences and technologies. The Council collaborates each spring with the Museum of Science and Industry in conducting a series of free lectures on technical subjects of interest to the public. Public and private libraries are represented on the Council's Library Committee, to the end that technical holdings will be of

greatest possible value to technical men and to the community. The Council is compiling a directory of research facilities in this area as a means of furthering the use of modern research methods by Chicago corporations and institutions.

The Council cooperated in the placement of returning Army and Navy veterans in jobs calling for engineering, scientific, and technical degrees. More than 700 veterans have been processed through the Council's office since V-J Day. In cooperation with the State Department, the Council sponsored a public meeting publicizing the objectives of the United Nations Educational, Scientific, and Cultural Organization. In programs of adult education, the Council works closely with such institutions of higher learning as The University of Chicago, Northwestern University, and Illinois Institute of Technology.

The Council's monthly publication, *Sci-En-Tech News*, is the central source for information about the monthly meetings of the 51 affiliated societies. The publication also contains information of general value to technical men.

The economic status of the members of the affiliated societies is the concern of the Council's Employment Committee, which regularly reports to the societies news of legislative and other developments affecting the employment status of the individual.

The Council's Speakers Bureau serves local club and church groups by providing qualified speakers on technical subjects. Allied with this activity are the speech courses run by the Council for the benefit of technical men who feel that their educational experience has failed to develop adequate abilities in the field of self-expression.

The Council's Program Committee is concerned with the quality of the monthly meetings of the affiliated societies and encourages cooperation among program chairmen to attain cross-fertilization.

ILLINOIS INSTITUTE OF TECHNOLOGY

Illinois Institute of Technology was formed July 24, 1940, through the merger of Armour Institute of Technology and Lewis Institute. The former had been established in 1892, the latter in 1896. The development program of the new institution was hardly underway when the country was plunged into war. Illinois Tech moved immediately into a vast, accelerated wartime training program.

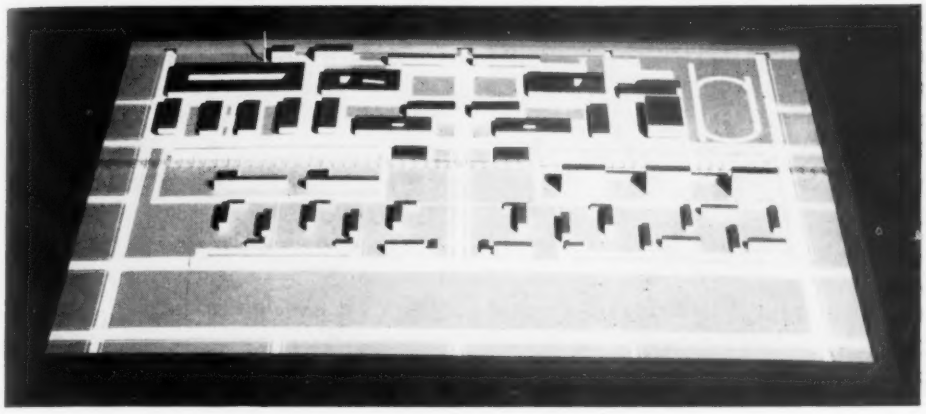
Total war prevented the Institute from immediately consolidating its educational position. However, its own temporary sacrifice enabled it to furnish 60,000 trained specialists to the Army, the Navy, and industry.

Peace for Illinois Tech meant not only reconversion problems in education, but a resumption of the educational solidification and the physical development the war had interrupted.

Major attention, aside from that directed strictly to matters of education and research, is focused on a long-range, much-needed building program. With slight exception, the Institute's building program was necessarily dormant during the war. Now it is going ahead rapidly.

When the two schools merged, the Lewis campus was located on Chicago's near West Side, and the Armour campus on Chicago's near South Side. For the wartime period this division of locations continued. Moreover, courses were given at other locations throughout the city. All are now centered on one campus with the exception of two departments, which are still housed near the Loop, but these eventually will move to the new location.

Illinois Tech's official address is 3300 Federal Street. The general area is one of the portions of Chicago slated for an extensive program of urban redevelopment. The Illinois Tech development will eventu-



THE FUTURE ILLINOIS INSTITUTE OF TECHNOLOGY

A PLOT PLAN SHOWING HOUSING (*foreground*) AND CLASSROOM AND RESEARCH BUILDINGS (*background*).

ally comprise about 105 acres. It will include buildings for education and research, and housing for students, staff, and faculty. It will extend from Thirty-first to Thirty-fifth Street and from South Michigan Avenue to the New York Central railroad tracks.

Three of the new functional buildings designed by Ludwig Mies van der Rohe, internationally known architect and head of Illinois Tech's Department of Architecture, have been completed. Two have been assigned to, and are being used by, Armour Research Foundation, the industrial research unit of the Institute. One has been assigned to the school's Naval Reserve Officers' Training Corps. A large building to house the Chemistry Department and one to provide new quarters for chemical engineering and metallurgy are nearing completion. Five war-surplus temporary buildings are in use for classes and for necessary adjunct services.

Work carried on at Illinois Institute of Technology is conducted by three units: the educational unit, with its undergraduate and graduate schools; Armour Research Foundation of Illinois Institute of Technology, specializing in industrial research; and the Institute of Gas Technology, which provides graduate education for the gas industry and conducts fundamental and applied research applicable to industry problems.

THE educational unit of the Institute now consists of three divisions, the College of Engineering, the Division of Liberal Studies, and the Graduate School. It also includes an Evening Division, in which both credit and noncredit courses are available in each of the areas of study.

Until three years before the consolidation of Armour and Lewis institutes, neither had a graduate school. In 1937 the Graduate School at Armour was established under the supervision of a dean. After the merger, one of the major objectives was to enlarge, develop, and strengthen the Graduate School. Although this program was slowed by the war, it was never halted. Since the war, it has been given increased emphasis. Today, graduate courses leading to master's and doctor's degrees are available in engineering and science.

Armour's College of Engineering was started with four-year courses in mechanical and electrical engineering. In 1895 Armour Institute and the Art Institute of Chicago established the Chicago School of Architecture, now Illinois Tech's Department of Architecture. Other engineering courses

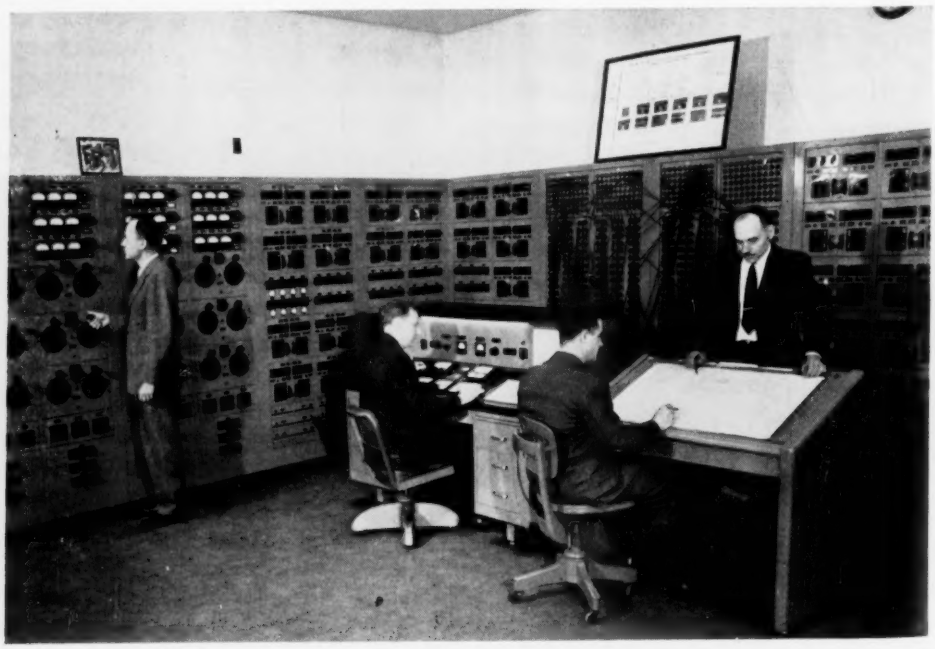
were established around the turn of the century and on to 1946, when the latest, metallurgical engineering, was started. A course in fire protection engineering, started in 1903, is still the only four-year course in this field given in any college in the United States.

Lewis Institute began as an academy and a junior college. Shortly thereafter it offered a four-year engineering course, granting the first degree in 1901. In 1912 it began to grant degrees in home economics. The degree in arts and sciences was first conferred in 1918, at which time the academy was discontinued. The arts and sciences courses became a part of the curriculum after the formation of Illinois Tech. In 1945 a special Division of Liberal Studies was established. The end of the war has brought a great expansion to this Division, which offers a complete liberal arts program. Illinois Tech is often thought of as a strictly engineering school for male students. On the contrary, it is coeducational in enrollment and offers a wide assortment of courses in liberal arts and sciences for both men and women.

Before World War II, Illinois Tech's daytime enrollment was about 2,200, with approximately 2,500 in the Evening Division. Current enrollment is 3,300 in the day courses and 4,000 in the Evening Division. The faculty has increased almost 100 percent since the end of the war.

Research of a fundamental nature is supported by grants of Institute funds or by contributions from outside sponsors. Applied research projects with completely specified objectives are in general handled by Armour Research Foundation.

In addition to research carried on by all departments, special laboratories are maintained for work in corrosion, photoelasticity, mechanics, fluid flow, catalysis, electron microscopy, spectroscopy, hearing, heat transfer, power systems engineering, electronics, engine noise, nucleonics, psychology, and biology.



THE A-C NETWORK CALCULATOR
IN THE ARMOUR RESEARCH FOUNDATION OF ILLINOIS INSTITUTE OF TECHNOLOGY.

IN SEPTEMBER 1936, three men with an idea, a purpose, and a capacity for hard work moved into three ground-floor rooms in the old Armour flats. Thus, with one project, an industrial research organization, later to be known as Armour Research Foundation of Illinois Institute of Technology, was founded.

From this rather inconspicuous beginning, the Foundation has grown rapidly, until today it has eight research divisions and one service division. These divisions, housed in various offices and laboratories, have completed more than 7,000 research projects for some 1,900 companies, government agencies, and trade and professional associations.

The Foundation is a nonprofit corporation, with the same trustees and officers as Illinois Tech, founded to render a research and engineering service to industry. Industry-sponsored research projects are accepted in confidence, with all patent and publication rights transferred to the sponsor.

Competitive projects are not accepted. Staff members are not permitted to do outside consulting or industrial advising and are under patent-waiver agreement to the Foundation.

One of the chief contributions of the Research Foundation is in the field of magnetic wire recording. It was here that the recorder was invented and developed.

Undergraduate or graduate students are not employed on industry-sponsored research projects. However, a limited number of Foundation-sponsored industrial research fellowships are available, combining a graduate educational program at the Institute with experience and training in industrial research techniques at the Foundation.

More than 150 research projects are now active in applied mechanics, ceramics, chemistry and chemical engineering, electrical engineering, mechanical engineering, metals, and physics. In addition to well-equipped laboratories in each research division, the following special laboratories and services are maintained:

National Registry of Rare Chemicals
Riverbank Acoustical Laboratory (Geneva, Ill.)
A-C Network Calculator Laboratory
Ohmite Laboratory of Precision Electrical Measurements
Precision Gage Laboratory
Armour Magnetic Recording Laboratories
Glessner House Laboratories of Lithographic Technical Foundation
Poulter Laboratory of High Pressure Research
Metals Heat Treating Laboratory
Welding Research Laboratory

Projects in fundamental research now in progress and supported by the Foundation are: high-pressure phenomena, transformer insulation, electromagnetic measurement of torque, crystallographic studies, stress corrosion, residual stresses in metals, anechoic chamber, hardenability measurements, abrasion resistance, magnesium alloys, diffusion in alloys, solidification under pressure, vacuum treatment of metal, and magnetostriction.

THE INSTITUTE OF GAS TECHNOLOGY at Illinois Institute of Technology was founded in 1941 to serve the gas industry in education and research. It was organized as a nonprofit corporation to specialize in scientific instruction and research pertaining to the production, distribution, and utilization of gas and its by-products.

Control of the Gas Institute is vested in a Board of Trustees composed of 22 men, 17 of whom are selected from candidates designated by member-companies. The remaining 5 are chosen by the Board of Trustees of Illinois Tech.

Research problems are considered under two headings, depending on whether the project is of recognized importance to the gas industry. If so, then all patents must be available royalty-free to members of that

industry; if not, the sponsor has full rights to any patents resulting from the project, except that the Institute retains a shop right.

Research projects now active include: fundamental study of reactions of carbon, oxygen, and steam at high temperatures and pressures; improvement of gasoline lantern and mantle; pilot-plant study of hydrocarbon reforming; partial devolatilization of coals in fluid bed; general study of flash pulverization; sulfur-resistant catalyst study; oil gasification in fluidized bed; organic sulfur in gas; gasification of coal and coke fines; flash pulverization of mineral ores; flash pulverization of coal; investigation of fly ash; autodestructive alkylation of propane; oil research; and high-pressure research.

MUNDELEIN COLLEGE FOR WOMEN

SINCE Mundelein College for Women is a small, liberal arts college, it has neither the facilities nor the backing to carry out extensive scientific research. Consequently, the aim of Mundelein's Science Department has always been directed toward improved undergraduate instruction, liberal in scope, but in practice preprofessional.

With this idea in mind, the administration has approved the set-up of equipment in the science laboratories considered the best in undergraduate schools in this locality.

The entire sixth floor is devoted to completely equipped science laboratories comprising two large chemistry laboratories, two physics laboratories, zoology, botany, geology, astronomy, embryology, and bacteriology laboratories.

Of special interest and value in the Science Department is a 120-foot Foucault pendulum, by which the rotation of the earth may be demonstrated and measured. Swinging nine stories in an otherwise unoccupied elevator shaft, the pendulum, longest of its kind in existence and only one of its kind, so far as is known, to have its movement recorded by an electric spark, is used by the Physics Department and is available to specialists in geophysics and astronomy and to others interested in scientific research. Besides recording the precession of the earth, the pendulum enables the Physics Department to keep a permanent record of the value of the gravitational constant for the Chicago area.

MUSEUM OF SCIENCE AND INDUSTRY

"SCIENCE DISCERNS THE LAWS OF NATURE: INDUSTRY APPLIES THEM TO THE NEEDS OF MAN."

THIS inscription, in bold relief around the rotunda of the Museum of Science and Industry in Chicago, epitomizes the purpose and achievements of this huge institution dedicated to the service and education of the public.

Below the inscription is a huge periodic table of elements, majestic symbol of man's physical resources—"the building blocks of nature." Radiating from this central court are the huge halls and galleries and beyond them the lesser halls and rooms devoted to man's progress in fitting the elements to his needs. Here are re-enacted the great historic experiments of science, and beside them whirr and throb the wheels, the pistons, the gears, and levers of application. More than 8 acres of dynamic working exhibits are gathered here for man to see, to wonder at, to ponder over, and, above all, to understand.

A visit to the Museum is a visit to another world—the world of knowledge, where the past rubs shoulders with today and steps on the heels of tomorrow. For this is the Museum's purpose—to provide the link of understanding between the ivory towers of

MUSEUM OF SCIENCE AND INDUSTRY

science and the smoke-stained chimneys of industry.

The visitor, on his first acquaintance with the Museum, is apt to find the introduction a bit startling. As he approaches, he is impressed with the majestic simplicity of the structure. Erected originally as the Fine Arts Building for the Columbian Exposition of 1893, the structure is based on the Greek classic as applied to a modern plan.

The effective use of Ionic columns, modeled after those of the Erechtheum, one of the temples on the Acropolis, provides an air of classic dignity and simplicity to a building which extends its front over 1,146 feet and provides a total floor area of around 14 acres.

Passing through the huge bronzed doors at the entrance, the visitor is suddenly engulfed in a world of light and color, space and sound. On either side of the north court in which he stands, and leading to the rotunda, are the massed colors of the nations of the world.

To his left and right open the wide entrances of the lesser halls. To the rear, immediately behind the periodic table, rise the superstructures of a coal-mine tipple and an oil derrick. From all sides come the noises of machines and the hubbub of milling throngs of visitors.

Despite the vastness of the spatial dimensions, there is an air of informality and intimacy the new visitor immediately senses. This is not a museum where one whispers through musty corridors to view endless glass cases of exhibits. Here the accent is on visitor participation. He may check his packages free. He may smoke. He may talk as loudly as he pleases. And above all, he finds, as he strolls along, that he may become a part of the show.

Here he finds a modern Midwest farm in full size. He may wander through the barn and look at the five types of dairy cattle in this country—life-size. He may walk through the fully equipped toolroom, through the dairy barn, or the farm kitchen. Or he may relax in the farm living room and view from a comfortable seat the display of field equipment at work in the surrounding fields.

In another section—devoted to steel—the visitor may see an old-time blacksmith

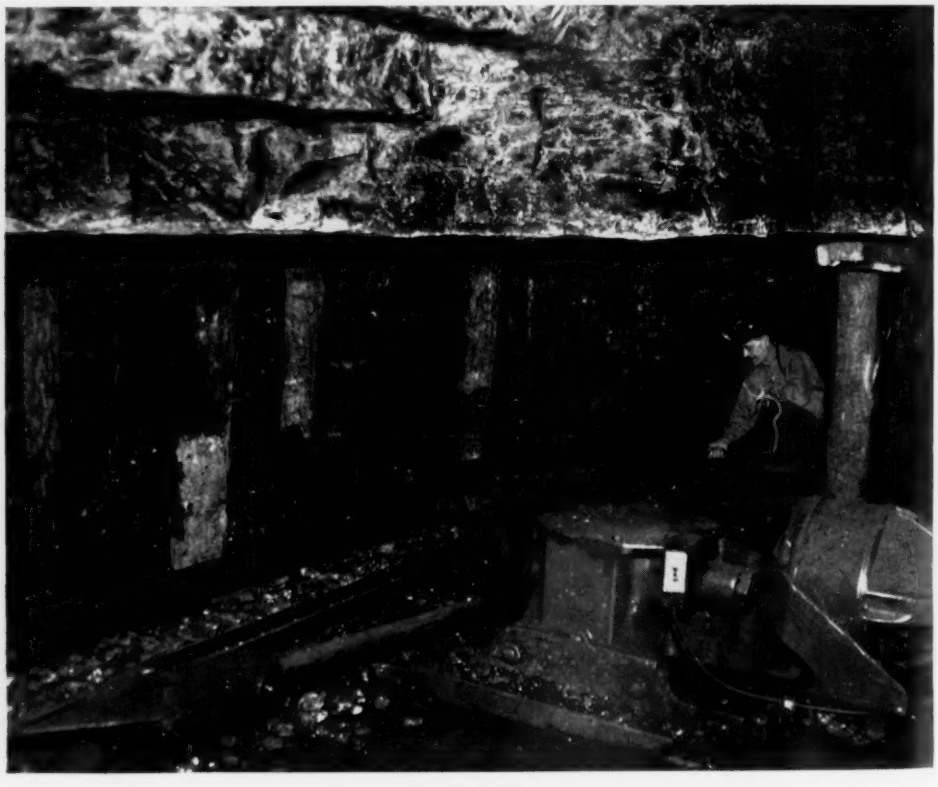
shop, again full scale, and at times even watch a blacksmith making nails here; for the philosophy of the Museum is not simply exhibition—it is demonstration as well. Continuing with the story of steel, the visitor finds a modern welding booth in operation and a working foundry where he may watch an actual "pour." During the war, this foundry produced a considerable amount of war material through such daily demonstrations.

Once the visitor has passed through the entrance doors, he will find himself the victim of a restless urge—the desire to see all there is to see in this trip. About halfway through the day he will finally conclude that he'll never make it—there's too much to see in a single visit. The best way is to concentrate on the things of specific interest and later see other exhibits.

The Museum is arranged in sections, each section being devoted to a broad field, and this in turn is broken into specific phases of that field in smaller sections. Transportation, for example, is one of the broad subjects. In one room, the history of transportation is developed in terms of the automobile, ranging from the "surrey with the fringe on top," vintage of 1904, to a 16-cylinder modern car. In an adjoining room, or hall, railroad transportation is covered with not only the early types of locomotives, but a miniature railroad representing one of this nation's largest railroad systems.

In a new exhibit, currently being constructed, the visitor will see the evolution of the automobile in terms of component parts such as brakes, tires, self-starter, etc.

In a life-sized replica of a street of 1910,



COAL MINE

REPRODUCED IN THE MUSEUM OF SCIENCE AND INDUSTRY.

MAIN STREET, 1910
REPRODUCED IN THE MUSEUM OF SCIENCE AND INDUSTRY.

the visitor himself becomes a part of the exhibit. Here he may inspect the fashions of that age in the shopwindows, see what early Chicago stores looked like, and view an old-time movie in the Nickelodeon.

Still studying transportation, the visitor can trace the history of sea travel through accurately scaled ship models ranging from the early Phoenician to the modern ocean liner. He may even launch a model ship himself in the Marine Room.

The history of aviation is another part of transportation. Models of famous planes, as well as the historic planes themselves, tell the story. Exploded models of motors, in operation, reveal the poetry of motion found in the complexity of the modern airplane power plant. Radar is explained so that the visitor may see how it operates to safeguard the airways of the nation.

In another section of the Museum, the story of petroleum is revealed, from the formation of the oil under the earth's surface millions of years ago to its conversion to gasoline—lifeblood of the nation—as well as other by-products.

In the field of basic science, the visitor may become acquainted with physics and perform many of the experiments that led the way to modern industrial miracles. He may see how the earth turns and observe the conversion of energy; he comes face to face with Newton's laws of motion, to make understanding as easy as an apple falling off a tree.

The story of radio shows how energy becomes music and voice; and in the telephone exhibit the visitor finds out not only how a telephone works, but how he himself sounds over the phone. There is a section

"THE MIRACLE OF GROWTH"
EXHIBIT PROVIDED BY THE UNIVERSITY OF ILLINOIS FOR THE MUSEUM OF SCIENCE AND INDUSTRY.

devoted to magnetism, to electricity, to optics. There are lectures and demonstrations, moving pictures, and equipment the visitor operates. There are full-size models and miniatures. There are dioramas and habitat groups—all devoted to one purpose —all there to tell a story.

Last year, 1,500,000 people attended the Museum. This year attendance is expected to be over 2,000,000. The average visit is three hours; the average group is a family. As many women as men come to the Museum, for there are special exhibits that attract each sex.

One of the latest exhibits is devoted to the growth and development of a human being, from conception to adulthood. It is in effect a frank, simple, dignified presentation of the "facts of life" and represents an outstanding contribution to the field of public-health education.

The Museum is a place of constant change. Major Lenox R. Lohr, President, summarizes the basic philosophy thus:

> We are not a repository for old relics. As soon as an exhibit has lost its educational value, as soon as the story it has to tell is outmoded, we dispose of it regardless of our personal feelings. We believe that only by constant change and improvement can we keep pace with the scientific discoveries of today and their industrial applications. Our mission is to interpret these things for the benefit of the public, and in so doing, we make more clear and better appreciated the American way of life.

NORTHWESTERN UNIVERSITY

NORTHWESTERN UNIVERSITY'S facilities for science are located on its Chicago campus in the Medical and Dental schools and on the Evanston campus in the new Technological Institute and the College of Liberal Arts departments of Chemistry,

Physics, Zoology, Botany, and Geology.

The Evanston campus. The greatest impetus to work in science at Northwestern has come in the past ten years, with the founding and development of the new Technological Institute. A magnificant Lannon stone structure with 10 acres of floor area and 2 miles of corridors, the building of the Technological Institute houses the departments of Electrical, Civil, Mechanical, and Chemical Engineering of the Institute, as well as the Physics and Chemistry departments of the College of Liberal Arts.

A gift of $6,735,000 by Walter P. Murphy made possible the establishment of the Technological Institute in 1939, and his bequest in excess of $25,000,000 two years later ensures its maintenance and development. The study program of the Institute is conducted on the cooperative plan, by which a student spends part of his educational time in school and part as an industrial worker.

The Department of Physics occupies approximately 110 rooms in an L-shaped wing in the southwest part of the Institute building. Laboratories and classrooms are on the first and second floors. Special installations such as the compressor for liquefaction of air and hydrogen, X-ray equipment, generator rooms, shops, and special research rooms are on the basement floor. Third-floor rooms are set aside for research projects.

A three-year program of fundamental physics research now in process is expected to lead to new and improved communication devices. It is an extension of wartime research, in which Northwestern physicists developed a new invisible-ray telephone and many new types of photoelectric cells used in the phone and in Army and Navy secret weapons. Among other projects being developed in the Physics Department is an infrared spectrometer, which records or measures atomic emission spectra in the near infrared beyond the range of photography. The spectrometer is designed particularly to go from 1 micron to 4 or 5 microns of wave length.

The Department of Chemistry, with quarters in the east front and southeast wing of the Institute building, is equipped to accommodate more than 600 students. Provision for exceptionally tall equipment, such as a controlled distillation column, is made by a shaft 75 feet high and 10 feet square, extending from the subbasement to the top of the building. At each floor level the walls of the shaft are provided with laboratory service.

Experimental work in catalysis and chemical reactions at high pressure, which was inaugurated at Northwestern a decade ago by Dr. V. N. Ipatieff, is carried out in a suite of specially designed rooms, including a separate bomb room and a room for gas analysis. Chemical experiments are made here in rotating bombs up to very high pressures. Extensive laboratories serve the Organic, Analytical, Inorganic, and Physical Chemistry divisions. To construct apparatus for chemical research, a well-equipped Glass-blowing Department is operated in the basement.

Among the subjects and fields being studied in this Department are the isotopes of oxygen, thermodynamics of high polymers, reaction kinetics with special emphasis on specific heats of gases, interraction of proteins with ions, steroid chemistry, wave mechanical equations, magnetic properties of matter, reactions under high pressure, organic chemistry of catalysis, pyrolysis and studies in carbohydrate and thiophene chemistry, catalytic hydrogenation, polarographic analysis and reaction mechanism, synthesis of pyridinium compounds, and reaction mechanics.

The northwest wing of the Institute building contains the Department of Civil Engineering. Available for undergraduate instruction as well as research are large

MAIN ENTRANCE, TECHNOLOGICAL INSTITUTE, NORTHWESTERN UNIVERSITY

THIS SECTION OF THE BUILDING CONTAINS LIBRARIES, OFFICES, AND EXPERIMENTAL ROOMS USED BY ALL DEPARTMENTS OF THE INSTITUTE. THE BUILDING CONTAINS 454,000 SQUARE FEET OF FLOOR AREA.

testing machines, the most powerful of which is a 5,000,000-pound hydraulic press, used for testing the strength of concrete columns and other members of dams and bridges.

A 1,000,000-pound hydraulically operated transverse universal testing machine is in the center of a large well in the civil engineering wing. In the cement and concrete laboratories investigative work is conducted independently or in cooperation with industry. Three special-temperature rooms are adjacent to the cement laboratory: a freezing room tested to a temperature of −55° F., an airtight dry room arranged to produce any temperature or

humidity approximating outside conditions, and a moist room designed to maintain a relative humidity of 100 percent at a temperature of 75° F.

Research being done includes the fatigue testing of materials and the problems of soil mechanics.

In the 28,000 square feet occupied by the Department of Chemical Engineering in the south-central wing are included such laboratories as unit operation, metallurgical research, furnace and ceramics, physicochemical measurements, and crushing and grinding. An exceptionally complete filtration section includes an Oliver filter, a Sweetland pressure filter, a Shiver plate and frame filter press, and a basket centrifuge.

The Department is now engaged in research in gas absorption that may lead to better methods of preparing certain important chemicals. A new method for storing natural gas in liquid form is being perfected in chemical engineering. It reduces storage space by more than 99.8 percent. In other experiments finer sizes of coal are cleaned by a Humphreys spiral (formerly used for recovering only heavy ores), and elimination of fine particles from wash water by a cyclone separator. This separator ordinarily is applied only to gases and liquids with larger precipitates.

The entire north-central wing, the Department of Mechanical Engineering, rests on separate foundations to prevent vibrations from being communicated to other parts of the building. This Department has been doing extensive work on the study and design of artificial limbs for the Army. Among other research going on in this

Hedrich-Blessing Studio

A LABORATORY IN PHYSICAL CHEMISTRY, NORTHWESTERN UNIVERSITY

WARD BUILDING, NORTHWESTERN UNIVERSITY, CHICAGO CAMPUS
THIS BUILDING HOUSES THE MEDICAL AND DENTAL SCHOOLS OF NORTHWESTERN UNIVERSITY.

Department is the study of air compressors for use in gas turbines.

Electrical engineering is in the northwest wing of the building, occupying about 32,000 square feet of floor space. The electrical machinery laboratory is in the basement near the power sources. Electronics, electrical measurements, and most of the communications laboratories are on the second floor. The high-voltage laboratory, 2 stories in height, occupies the end of the wing. The voltage of the impulse equipment is higher than any other in the Chicago area.

Among the research projects underway in the Electrical Engineering Department are those in the following fields: aerial measurements and specialized computing procedures, microwave theory related to wave guides and lens systems, closed-

cycle control systems, analogue-type computing machines, and cold cathode power tubes.

The Chicago campus. Northwestern University has embraced a forward-looking program in medicine. A $100,000,000 medical center is now being established on the Chicago campus at Lake Shore Drive and Chicago Avenue. Already located on the campus are the Medical and Dental schools and two affiliates of the Medical School, Passavant and Wesley Memorial hospitals. It is expected that the completion of the project will require twenty-five years.

Key structure in the planned new development will be an Institute for Medical Research to supplement clinical and research facilities of the campus and serve as the initiating and coordinating agency for a vast program of medical research. Another project proposed for the new center is an Institute of Geriatrics, which will undertake investigation in the field of degenerative diseases and the problems of aging.

Erection of a clinical and research unit is assured through a bequest of $1,500,000 from the late Mrs. Joy Morton. The Veterans Administration soon will build on the Chicago campus a 600-bed cancer hospital, which will be the finest institution for the study of cancer in the world.

Work is being done in seventeen different fields of medical research, including pathology, surgery, pediatrics, nutrition, ophthalmology, urology, dermatology, bone and joint diseases, and malignant diseases.

PROPOSED INSTITUTE FOR MEDICAL RESEARCH, NORTHWESTERN UNIVERSITY

A proposed Department of Aeronautical Medicine will study the countless new medical problems posed by aviation, such as altitude and pilot fatigue. Occupational diseases and other health hazards in industry will be investigated by a newly created Department of Industrial Medicine.

Extensive research is being carried on in the fields of respiration, vascular disease, cancer, and congenital heart disease. Other research now in progress includes the study of streptomycin as a treatment for tuberculosis and development of an improved electronic instrument, a fluorimeter, which will increase the range and depth of chemists' research.

The University has recently established an Institute for the Study of Rheumatic Fever, the first such institute in any school of medicine in the nation. Its laboratories are housed on one entire floor in the Municipal Contagious Disease Hospital in Chicago.

A Department of Nutrition and Metabolism was established this year under the chairmanship of Dr. Tom D. Spies, internationally known authority in nutrition. The University hopes to develop, in conjunction with the Spies committee, the nation's broadest program of research in nutritional diseases.

The Medical School proper occupies the first seven floors and the eighteenth-floor tower of the Montgomery Ward Building, and the Dental School, the eighth to the thirteenth.

Working closely with the Medical School, the Northwestern Dental School is equipped with modern clinics conducted by the departments of Operative Dentistry, Prosthetic Dentistry, Oral Pathology, Children's Dentistry, Orthodontia, Diagnosis, and Oral Surgery and Radiology.

Principal research has dealt with dental caries, diseases of the gums, and materials used in dentistry. A service that has expanded since the war is that of training dental hygienists as auxiliary personnel to work in the dental office and in public-school dental-health programs.

DURING the war many of Northwestern's facilities were used in thirteen different types of war training programs for the Army, Navy, and Marines, and for civilians in war industries. Of the 49,225 total attendance, 36,124 were Naval trainees, with 6,210 trained in the Navy Radio Operators' School on the Evanston campus and 26,570 in the Reserve Midshipmen's School, including the Commissioned Officers' Indoctrination School on the Chicago campus. The Navy V-12 and Navy R.O.T.C. in Evanston trained 2,338.

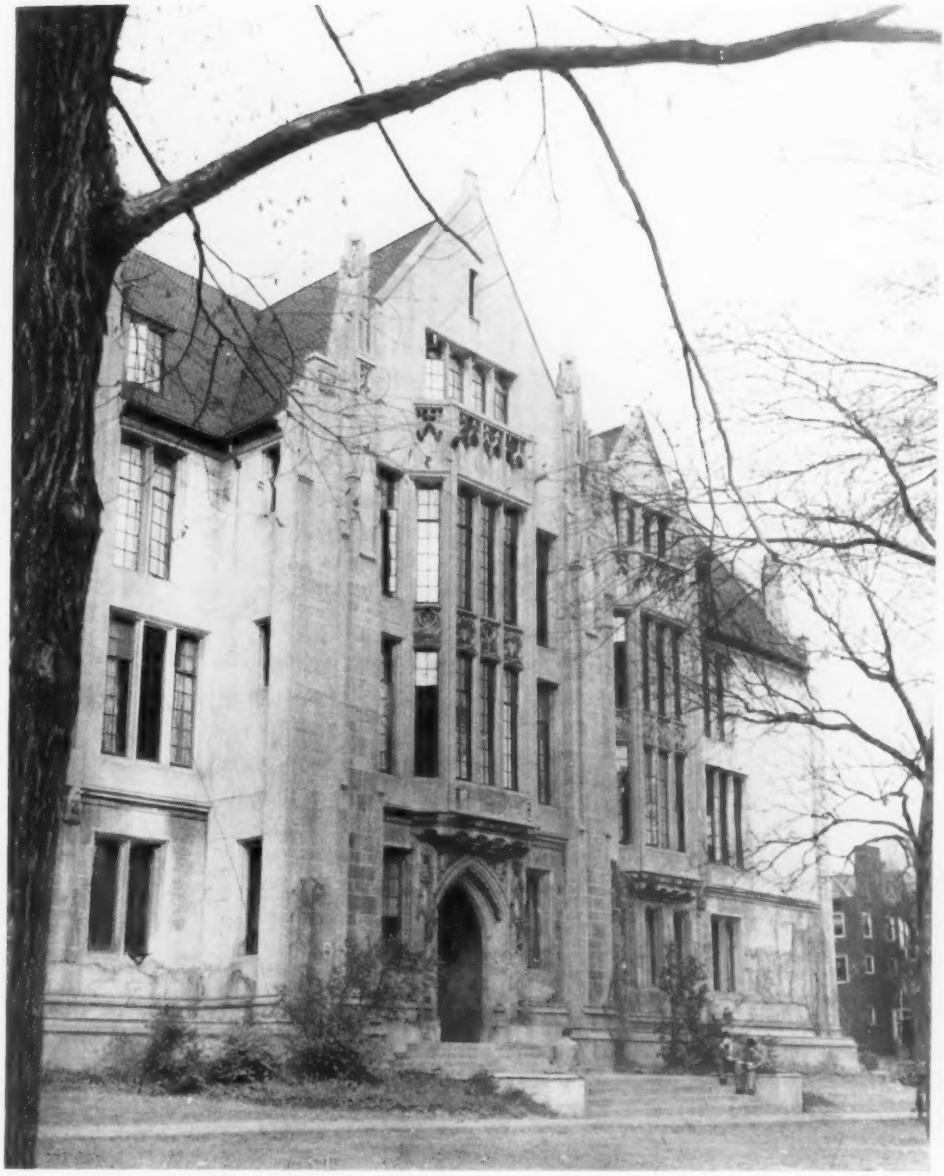
Other programs conducted for the armed forces were Civilian Pilot Training and Navy Flight School, Army, Navy, and Marine Reserve programs, Army Signal Corps, Army and Navy medical and dental programs, and the Army Civil Affairs Training School.

War research also was extensive, with fifteen different government projects being carried on in the physical sciences, five in chemistry, four in physics, three in electrical engineering, and one in mechanical engineering. War research was done by the Medical School on twelve different projects of its own, in physiology, neurology, and surgery.

THE UNIVERSITY OF CHICAGO

THE following account of scientific research at The University of Chicago stresses wartime accomplishments. The present work of the three institutes that have sprung from the Metallurgical Laboratory is described on pages 482–94.

The atomic bomb. During the war years The University of Chicago was one of the major centers of the war-research program. In this capacity it acted as host and contracting agency for the Metallurgical Labor-



ECKHART HALL, UNIVERSITY OF CHICAGO

THIS BUILDING, WHICH HOUSES THE INSTITUTE OF NUCLEAR STUDIES AND THE DIVISION OF PHYSICAL SCIENCES, WAS A CENTER DURING THE WAR FOR RESEARCH LEADING TO DEVELOPMENT OF THE ATOMIC BOMB.

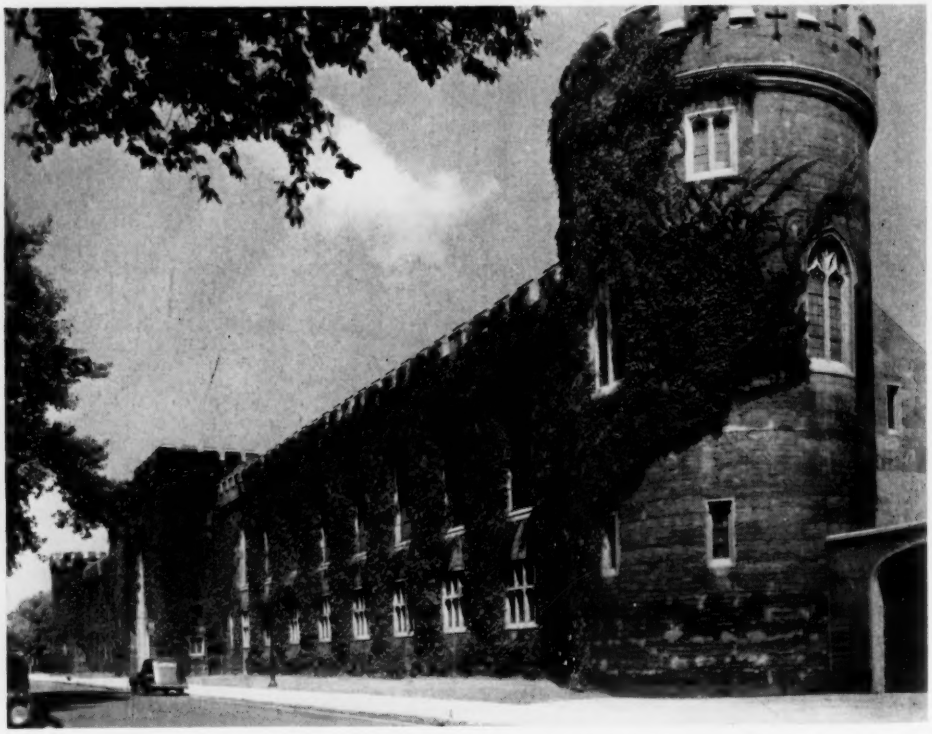
atory, now the Argonne National Laboratory, where fundamental investigations underlying the development of the atomic bomb were carried out. An idea of the magnitude of the University's war effort is provided by the budget figures for the year 1944–45: an income of $32,390,945, and a total staff of 8,000, approximately half of whom were engaged in government work.

The Metallurgical Laboratory was a large part of this effort and had associ-

ated with it other installations in or near Chicago. Until June 30, 1945, the University administered the Clinton Laboratories at Oak Ridge, Tenn., designed and operated by E. I. du Pont de Nemours & Company, making use of the experience obtained in the Metallurgical Laboratory. Both the Metallurgical Laboratory and the Clinton Laboratory assisted the Du Pont Company at the production plant at Hanford, Wash.

The Metallurgical Laboratory was first carried on under the auspices of the Office of Scientific Research and Development and later under the Manhattan District of the Army Engineers. The atomic age began December 2, 1942, when Enrico Fermi, Nobel prize winner and now Charles H. Swift Distinguished Service Professor of Physics at the University, and a small group of physicists achieved release of atomic energy in a self-maintaining nuclear chain-reaction pile in a squash-racquets court in the West Stands of Stagg Field. Operated at a low level, this pile served as the prototype of a pilot plant at Oak Ridge, Tenn., and of the vast production plant at Hanford, Wash. The Argonne National Laboratory is now being operated by the University for the Atomic Energy Commission on a basis that permits participation by the staffs of 25 universities and other research organizations in the Middle West interested in nuclear research. Walter H. Zinn, Associate Professor of Physics at the University, is Director of the Argonne.

Although the Metallurgical Laboratory engaged the services of most of the members of the University's Department of Physics and Chemistry, it was fundamentally a great cooperative effort of the Army, scientists of American universities and



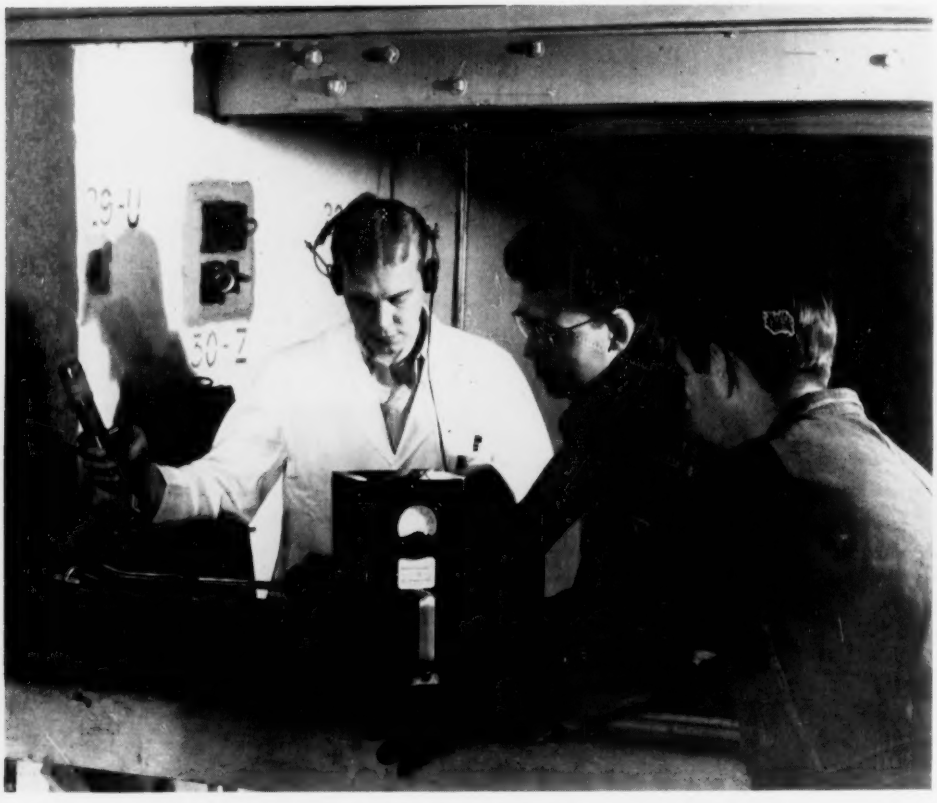
WEST STANDS, STAGG FIELD, UNIVERSITY OF CHICAGO

THE FIRST NUCLEAR CHAIN REACTION WAS DEMONSTRATED HERE ON DECEMBER 2, 1942.

A URANIUM PILE, ARGONNE NATIONAL LABORATORY, PALOS PARK

THIS PILE IS THE REASSEMBLED ORIGINAL PILE FROM STAGG FIELD. A CORNER OF THE SHIELDING WALL IS SHOWN HERE. THE BALCONIES CARRY THE CONTROL RODS THAT OPERATE THE PILE. THE OPERATORS ARE ABOUT TO PUSH INTO THE PILE A SAMPLE TO BE IRRADIATED.

industrial organizations, engineers, industry, and public agencies. Members of the Metallurgical Laboratory, in addition to their key achievement of the self-sustaining pile, determined the chemical properties of plutonium, devised a method for its chemical separation from uranium and fission products, and in general solved the problems involved in mass production of plutonium. All this work was carried on with submicroscopic amounts of plutonium, by means of "tracer" chemistry. The step



SCIENTISTS AT THE ARGONNE NATIONAL LABORATORY

A CLOSE-UP OF THE OPERATORS SHOWN IN THE PREVIOUS PHOTOGRAPH ALSO ILLUSTRATES A SAMPLE MADE RADIOACTIVE IN THE PILE AND THE RECORDING EQUIPMENT ALWAYS USED TO BE SURE THAT THE OPERATORS NEVER EXPOSE THEMSELVES TO DANGEROUS AMOUNTS OF RADIOACTIVITY.

from this laboratory study to the design of the Hanford Works based on it was of the order of ten billion times. In the Laboratory, Dr. Glenn T. Seaborg, of the University of California, and others identified two new transuranic elements, numbers 95 and 96.

Biological warfare. While the physical scientists were exploring in the atomic field, the botanists of The University of Chicago were commissioned by the Chemical Warfare Service of the U. S. Army to arm the nation against a biological war.

Initial research on plant controls for crop destruction resulted in 1941 at the beginning of the war from a suggestion made to the Secretary of War by Ezra J. Kraus, Chairman of The University of Chicago's Department of Botany. Dr. Kraus, a pioneer in the use of synthetic growth-regulation substances, foresaw the possibility of the enemy's using compounds for herbicidal purposes against the Allies. Experiments carried out at the University under his direction provided unequivocal proof of the herbicidal activity of many growth-regulating substances.

Crop- and weed-destructive properties of 1,100 different chemical agents, which would have been used to lay waste food supplies of the enemy had he resorted to biological warfare, but which also have great benefits for peacetime agriculture, were investigated by the Chemical Warfare

Service of the U. S. Army in laboratories at The University of Chicago, The Ohio State University, Camp Detrick (Frederick, Md.), and the U. S. Plant Industry Station (Beltsville, Md.). Research at the University was conducted in Hull Botanical Laboratory directly across the street from the plutonium laboratory, where the basic secrets leading to the production of the atomic bomb were developed.

Although biological warfare was not used in military operation in World War II, the botanists reported that enough information was discovered on the possibilities of plant destruction to show that it is imperative that the nation be alerted on methods of use of such compounds and methods of combating their ill effects.

The rapid ending of the war prevented field trials, in an active theater, of the synthetic agents, which would have, without injury to animal or human, affected certain growing crops. The same principles, however, are now being applied to destroy noxious weeds throughout thousands of acres of pasture land in the Western states and growing fields of sugar cane, rice, pineapple, and other crops.

Application of certain of the 1,100 organic compounds tested by the Laboratory could have deprived the enemy of numerous crops—the loss of which would sometimes have been discovered only after cultivation.

A wartime chemical—isopropylphenylcarbamate—first used in Great Britain, and especially toxic to grasses, was found to kill field-grown winter rye and to seriously damage grown oats when the compound was applied to the soil in sawdust at seeding time.

Young cabbage plants, soybeans, tomatoes, sweet potatoes, and sugar beets, sprayed with 2,4-dichlorophenoxyacetic acid (first used as a growth-regulating compound by Professor Kraus) were killed or stunted in growth with amounts as low as 0.1 pound applied to a single acre.

Bacteriology and parasitology. During the war, the Department of Bacteriology and Parasitology cooperated with the Department of Biochemistry in investigations on the metabolism of malarial parasites. This work has been continued in the Department under the direction of Dr. J. W. Melder, Instructor in Biochemistry, and has been broadened to include studies on the metabolism of trypanosome and helminth parasites. Special emphasis is being placed on the effect of the immune reactions of the host upon the metabolism of the parasite.

Dr. W. H. Taliaferro, Eliakim H. Moore Distinguished Service Professor of Parasitology and Chairman of the Department, is continuing his investigations on the mechanism of immunity against the animal parasites. He is at present particularly interested in the cellular basis of immunity and in the effect of X-rays and the nitrogen mustards in reducing immunity in experimental malaria.

Beginning before the war and continuously since, Dr. Clay G. Huff, Professor of Parasitology, and his associates have concerned themselves with the exoerythrocytic stages of various malarial parasites. They have demonstrated the tissue stages of four species of avian malaria which precede the development of the stages in the blood. The behavior of these stages in immunity and under the influence of drugs has been studied.

Dr. Stewart A. Koser, Professor of Bacteriology, is conducting experiments on bacterial nutrition, with particular emphasis on the vitamins and their relation to microbic activities.

Dr. William Burrows, Associate Professor of Bacteriology, is studying the nature of effective immunity to infection with the cholera vibrio and other enteric bacilli.

Dr. F. B. Gordon, Associate Professor of Bacteriology, is conducting research on infantile paralysis and other diseases of the central nervous system caused by viruses.

The physiological characteristics and

ALBERT MERRITT BILLINGS HOSPITAL, UNIVERSITY OF CHICAGO

pathogenicity of the nonsporulating anaerobic bacteria, particularly those associated with puerperal fever, are being investigated by Dr. K. Eileen Hite, Instructor in Bacteriology. Recent or current investigations by graduate students working with Dr. Hite have been concerned with the conditions for production of enterotoxin by, and the effect of antibiotics on, food-poisoning staphylococci and the antibiotic activity of certain molds against Brucella.

Pathology. During the war, Dr. Paul R. Cannon, Chairman of the Department of Pathology, and members of the Department concentrated on studies of protein nutrition in relation to infection and resistance and on problems of amino acid metabolism in relation to health and disease. These studies have led into investigations concerning cancer, nutrition, wound healing, vitamin needs in relation to protein synthesis, and the like. During the war Dr. C. C. Lushbaugh, Instructor in Pathology, was active in the study of the effects of nitrogen mustard, out of which came the use of this substance in the treatment of certain neoplastic diseases. Dr. Paul E. Steiner, Associate Professor of Pathology, during the past decade has been studying the problem of cancer-inducing agents that may be present in human tissues. Dr. Eleanor M. Humphreys, Professor of Pathology, has investigated vascular diseases, particularly rheumatic fever, and other diseases of connective tissues.

Pharmacology. Early in 1941 the Department of Pharmacology, under the chairmanship of Dr. E. M. K. Geiling, began to cooperate in two wartime projects: the Toxicity Laboratory for the study of chemical warfare agents and the Antimalarial Project for the study of potential drugs for the treatment of malaria. The Toxicity Laboratory is continuing under

the sponsorship of the U. S. Army. The present work of the "Tox Lab" will be described in a later issue of the SM.

The malaria research problem was sponsored by the O.S.R.D. Committee on Medical Research. More than 1,000 compounds were studied for their antimalarial activity and acute and chronic toxicity. Experiments on the intermediate metabolism of drugs were also carried out, especially with quinine and atabrine. One of the metabolic products of quinine was isolated for the first time. Identification of its structure led to the synthesis of a large number of potentially valuable compounds.

Since the war, this Department has undertaken research projects for the U. S. Navy in anesthesiology and for the U. S. Public Health Service in chemotherapy and drug metabolism. The pharmacology of a number of new drugs is being investigated. Work on the application of radioisotope technics to pharmacology is well underway.

Zoology. In a general way, the research activities of the Department of Zoology fall into five broad categories: embryology, physiology of reproduction, genetics, evolution, and ecology.

Embryology is represented by Professor Paul Weiss and Assistant Professor Ray L. Watterson. Dr. Weiss and his students work primarily on problems associated with the development of the nervous system in vertebrates, especially amphibians. They have been concerned, for example, with the growth and differentiation of individual nerve fibers and with the various factors that control and modify these processes. During the war Dr. Weiss was called upon by the Office of Scientific Research and Development to apply some of his principles and methods to problems concerned with nerve regeneration. The relation of this to war wounds involving the nervous system and to war surgery is obvious. Dr. Watterson works on the embryonic stages of chickens and is particularly concerned with an analysis of the development of blood vessels as the embryo matures. For example, he has traced in a meticulous way the origin of the pattern of blood supply surrounding the nerve cord.

The physiology of reproduction is being studied by Professor Carl R. Moore, Chairman of the Department of Zoology, and by his colleague, Dr. Dorothy Price, Assistant Professor of Zoology. They work with various sorts of mammals, primarily rats, guinea pigs, hamsters, and opossums. Many notable contributions about the action of sex hormones and other endocrines have emerged from Dr. Moore's laboratory. He has been a leading figure in showing that certain hormones produce certain effects on the reproductive system of both male and female mammals. Dr. Moore is also using the opossum for some very novel studies, attempting to analyze the role of hormones in certain phases of embryological development. The opossum is uniquely adapted to this study because the young are born in a very immature state, lying outside the body of the mother attached to a nipple, and thus can easily be experimented upon *in situ*. The young are embryos, to all intents and purposes. Last summer Dr. Moore and Dr. Price worked at three different altitudes in Colorado, attempting to analyze the relation between altitude and reproductive effectiveness, using rats as experimental animals.

Genetics is represented by Dr. Sewall Wright, Ernest D. Burton Distinguished Service Professor of Zoology and Associate Professor H. H. Strandskov. Dr. Wright is internationally known for his studies in population statistics and in physiological genetics. In the former field he has developed a coherent mathematical theory to deal with the distribution of genes in terms of evolutionary time and with the important categories of factors that affect this distribution. In the latter field he has

made significant contributions on the relation of the physiological action of genes in the formation of hair and color patterns in guinea pigs. Dr. Strandskov is an authority in the field of human genetics. His researches have been concerned primarily with human twins.

Ecology is represented by Professors W. C. Allee, A. E. Emerson, and Thomas Park. Dr. Allee has concerned himself primarily with the study of animal aggregations and the social order exhibited by various groups of animals. As a consequence of his many years of research, he has been led to the formulation of broad philosophical principles that afford support for the idea that there is an underlying cooperation exhibited by groups of organisms. It is usually assumed that animals are only competitive or antagonistic to one another. Professor Allee's researches have convinced him that this is by no means always true and that "unconscious cooperation" in biology is a principle of fundamental significance. Professor Emerson is one of the world's authorities on termites, and he has used these organisms in deriving broad biological principles about animal distribution and taxonomy. In addition, he has formulated a number of interesting generalizations about evolution and the formation of species. Dr. Park is analyzing, by laboratory methods, the quantitative nature of population competition between two species of organisms grown under carefully controlled conditions. In these studies he is using two small beetles, both of which inhabit flour and whose total environment can be precisely controlled.

Physiology. Dr. Ralph Gerard and his colleagues in the Department of Physiology worked for two decades on the chemical and electrical properties of nerve and brain. They are now engaged on a special research project to correlate these two aspects more closely, for the chemical changes supply the energy that enables the nervous system to function, and the electrial changes offer the most delicate measure of its functioning. There is reason to believe that the extra energy needed for activity, as compared to the resting condition, is obtained by nerve by burning phosphorus compounds of fat or protein. This is one problem that should be settled soon, especially with the aid of radioactive phosphorus. Much the same methods should reveal whether a phosphoprotein moves out along nerve fibers from the main part of the nerve cell, and how such movement is altered under various conditions. Further, by interfering with one or another step in the chemical sequences occurring in nerve or brain and noting the resultant disturbances in functioning, it should prove possible to identify the particularly important steps in normal function. This can be done by adding appropriate drugs or chemicals to isolated nervous tissue or by adding them to the blood to be carried to the nervous system still in the animal. From such studies will come ultimately an understanding of how the brain works normally and so of what the aberrations are in disease and how to correct them.

Obstetrics and gynecology. The Department of Obstetrics and Gynecology under the direction of Dr. Wm. J. Dieckmann, Chairman, has sponsored or aided in the development of the following:

1. Decreasing the number of babies that are born dead or die during the first month of life by emphasizing the importance of proper care during pregnancy and the omission of drugs during labor if the baby is born prematurely or by Caesarean section. Lowering the number of deaths of mothers by intelligent prenatal care and by repeated hospitalization whenever necessary. The use of glucose and saline solutions and of blood transfusions whenever indicated. All of these and the careful supervision and instruction of the resident staff has resulted in a maternal mortality of approximately less than 1 per 1,000.
2. Ergotrate, which is used to prevent bleeding after delivery.
3. Study of various analgesic and anesthetic drugs used in childbirth.

4. Clarification of the two general types of high blood pressure that may occur in pregnant patients.
5. The determination of standards for determining which pregnant patients are anemic.
6. Studies of the various agents used to cure various infections causing leucorrhea.

UNIVERSITY OF ILLINOIS

CHICAGO PROFESSIONAL COLLEGES

THE University's professional colleges of Medicine, Dentistry, and Pharmacy, and the 485-bed Research and Educational Hospital are located on a 12-acre campus. More than 1,250 students receive instruction each year from the staff of 900 faculty members. The Chicago plant of the University is valued at $10,000,000. The professional colleges and hospitals are headed by Dr. A. C. Ivy, who serves as Vice-president of the University.

The University's College of Medicine, staffed by 800 physicians, is the largest medical school in the nation from an enrolment standpoint. Half the student body on the Chicago campus of the University, or 630 students, is enrolled in the College of Medicine. The College has been operated by the University since 1913. Almost all members of the staff are actively engaged in research in addition to teaching.

In a study on convalescence, Drs. Warren H. Cole and Robert W. Keeton have determined that it is possible to eliminate insufficiencies arising from operations by utilizing various forms of treatment. They are now conducting tests to determine the speed of convalescence. The Department of Surgery, headed by Dr. Cole, also has developed a new method of treatment for strictures of the common bile duct.

Dr. G. E. Wakerlin, head of the Department of Physiology, is currently conducting research on the prevention and treatment of experimental hypertension as a promising approach to the important problems of cardiovascular diseases.

Recently, the University contributed to public-health education by presenting "The Miracle of Growth," a dramatic exhibit of growth and development of the individual from conception through adulthood, to the Museum of Science and Industry [see page 461]. The display, conceived and created by the Department of Medical and Dental Illustration, utilizes a variety of exhibit techniques. It will be used by school children, by parents for the instruction of their children, and by the general adult public as an impersonal source of accurate information.

During the past year the Department of Pharmacology supervised all toxocological analyses for state's attorneys and coroners in the 52 counties of Illinois. Research in pharmacology has included all types of blocking agents such as "benadryl," curare-like drugs, sympathicolytic drugs which may prevent high blood pressure, and new analgesic drugs more potent and less habit-forming than morphine or heroin.

The Illinois Neuropsychiatric Institute, headed by Dr. Francis J. Gerty, has studied such problems as glucose metabolism in acute psychoses, isolation of an anti-insulin factor in schizophrenia, and the use of carbon-dioxide inhalations in the treatment of several forms of mental disorder. Dr. Warren S. McCulloch has mapped out the functional relationships of the cortex and nuclei of the brain in areas in which such mapping had not been previously performed. A new electric stimulator, made by Craig Goodwin, has been used successfully in the work. Dr. Frederic A. Gibbs and Erna L. Gibbs have been engaged in intensive research on epilepsy, involving particularly the relationship of disturbance in the temporal cortex of the brain to psychomotor seizures. They also have conducted studies on blood passing to, and coming from, the brain, by means of a special technique involving direct approach to the blood supply of the internal carotid artery and

DENTISTRY, MEDICINE, AND PHARMACY BUILDING, UNIVERSITY OF ILLINOIS
THE CAMPUS OF THESE PROFESSIONAL COLLEGES IS LOCATED ON CHICAGO'S NEAR WEST SIDE.

internal jugular vein. Dr. Gibbs has made studies of the electrical activity of the deeper portions of the brain and has been active in promoting a program he established in Illinois two years ago for the prevention, diagnosis, and treatment of epilepsy.

The University's College of Pharmacy ranks as the only accredited school of pharmacy in the state. The fifty-one-year-old college has a staff of 36 full-time members to instruct its current registration of 430 students. Seventy percent of the state's pharmacists are graduates of the state university.

Another integral part of the Chicago campus of the University of Illinois is the College of Dentistry, with its 160 students and 40 faculty members. The University assumed control of the College in 1913.

In dental research Dr. Isaac Schour has studied the growth of teeth and the role of nutrition and the endocrine glands in tooth development. He laid the foundation of tooth-ring analysis as a biologic method of analyzing the health and nutritional status of the growing individual. Recently, he conducted clinical studies in Italy on the effects of malnutrition on caries and periodontal disease.

Dr. Stanley D. Tylman has gained recognition as the first to use plastics in the construction of artificial ears, noses, and fingers. He has been working with flexible plastics for six years and has returned many patients, including disfigured service-

men, to a normal appearance through the use of artificial restorations.

The University's program of providing facilities for teaching, research, and treatment in the health professions also includes plans for a college of nursing, under the direction of Mrs. Ann Lucille Laird, R.N.

At the present time, the University offers orthopedic, neuropsychiatric, and pediatric nursing courses for senior cadet and affiliate student nurses. Plans also have been formulated for a four-and-a-half-year course in nursing education.

The 485-bed Research and Educational Hospital operated by the University ranks among the nation's leaders in its field. A total of 140,000 outpatient visits are handled annually by the hospital's 24 clinics, and an additional 6,000 patients receive bed treatment each year.

The Hospital, operated and staffed by the University since 1926, has attained a high degree of selectivity in the admission of patients, based upon their teaching and research value. Hospital care and clinic treatment have been limited to residents of the state who are unable to pay for such services.

Through the leadership of Dr. Ivy, a large research program has been inaugurated with the proposed construction this fall of the Institution for Tuberculosis Research and the Aero Medical and Atmospheric Environment Institute.

The University has been designated by the U. S. Public Health Service as the sole facility in the nation for the manufacture of BCG (bacillus of Calmette and Guérin) vaccine. Wholesale processing of the preparation will be launched in a new tuberculosis research hospital costing $361,250. The University and the Chicago Municipal Sanitarium will work in close cooperation on the project. The vaccine, it is hoped, will extinguish the threat of tuberculosis in the U. S. within twenty to forty years. University scientists associated with the project are convinced that the need for sanitariums treating the disease can be eliminated within that time if BCG is administered to every child and adult not now infected with tuberculosis. Immunity conferred by the vaccine lasts from five to seven years. The preparation is taken from the same germ strain that was isolated from an infected cow by French scientists Calmette and Guérin in their original experiments in 1908.

The Aero Medical and Atmospheric Environment Institute will be erected and partially equipped at the cost of approximately $400,000. The laboratory, destined for the study of atmospheric effects on the body, will provide the University with a complete program in the fields of atmospheric environment and aviation medicine. The Institute is expected to give the University the most complete over-all aviation medicine program of any college in the nation and will provide the Air Force with trained personnel in the specialized field.

A prospective $13,000,000 building program comprises a research institute for chronic illness and geriatrics, a hospital for cancer research, an experimental research building, a drug-plant research station, a nurses' residence, student residence halls, a power plant, and a utilities distribution system.

The staff of the University's professional colleges does not confine its activity to Chicago alone. Hardly a day passes that one member or more of the staff does not speak to some group downstate. A large proportion of the patients in the hospitals, referred to the University by their own physicians, reside in downstate areas. At the present time the University is considering the extension of its pediatric service, its intern service, and its resident physician service to downstate residents. The University also is aiding in a plan to increase the number of physicians per capita in southern Illinois.

INSTITUTE FOR NUCLEAR STUDIES, THE UNIVERSITY OF CHICAGO

By SAMUEL K. ALLISON

Professor Allison (Ph.D., Chicago, 1923) did research at Harvard and the Carnegie Institution before going to the Department of Physics, University of California. A specialist in nuclear physics, he has been at The University of Chicago since 1930. Dr. Allison is Director of the Institute for Nuclear Studies.

DURING the recent war The University of Chicago administered and housed the Metallurgical Laboratory, acting at the request of the government. The Metallurgical Laboratory was part of the Metallurgical Project, whose task was the initiation of the uranium fission chain reaction and the development of methods for the production of plutonium in amounts of military significance. Almost the entire staff of the Physics and Chemistry departments of the University became associated, in part or in full time, with the work of the Project, and many persons from the Biological and Medical divisions added their contributions. The majority of the wartime staff, of course, was contributed by universities and industries widely scattered over the United States.

To satisfy the demands of military security in wartime, the name "Metallurgical" was chosen as a blind to cover the actual work underway, and, in fact, the original Project seemed to demand the services of a small group of experimental and theoretical physicists interested in nuclear physics. The term "Metallurgical" soon became less of a misnomer, however, and during one period it actually described the major part of the Laboratory's work. This misadventure in security indicates how the program broadened into the fields of chemistry, biology, medicine, metallurgy, meteorology, and even into ichthyology.

As the collaborative effort surmounted obstacle after obstacle and it became clear that the Project would succeed, leading members of the University faculties and of its administrative staff became more and more enthusiastic about keeping together, in some more permanent form, groups of scientists interested in, and stimulated by, the great developments in nuclear physics and chemistry. In the fall of 1945 the University administration, with the approval of the Board of Trustees, announced the founding of three institutes as an outgrowth of this idea. They became known as the Institute for the Study of Metals, the Institute of Radiobiology and Biophysics, and the Institute for Nuclear Studies.

The program, in very broad outline, of the Institute for Nuclear Studies, is to conduct researches in nuclear physics, radiochemistry, and the chemistry of the separation of isotopes. In it an attempt is being made to attain the complete fusion of the sciences of physics and chemistry, at least in their advanced aspects. At the time of founding the Institute, it was not clear to what extent the program could involve direct contributions to the development of atomic power as a peacetime project. Some members thought that such a scientific-industrial program might be the core of the Institute's activities. However, it has become the policy of the nation, as expressed in the atomic-energy legislation passed by Congress, not to make public nor share with other countries the methods and processes of the application of atomic power during the present fretful state of the world. This policy made it impossible for the Institute, as a part of the University, to participate

directly in such an effort. Several Institute members, in their capacity as consultants to the laboratories of the Atomic Energy Commission, frequently visit these institutions and lend such aid as they can to the industrial and military projects being undertaken there.

In the organization of The University of Chicago, the Institute for Nuclear Studies and the Institute for the Study of Metals are parts of the Division of the Physical Sciences, which includes the departments of Astronomy, Chemistry, Geography, Geology, Mathematics, Meteorology, and Physics. The administrative officer most closely associated with it is, therefore, the Dean of the Physical Sciences.

Academic appointments as professors of various ranks on the staff of the Institute for Nuclear Studies are in no way different from appointments in the traditional departments. The Institutes, however, can make technological appointments of a type not found in the departments; thus, appointments such as Electrical Engineer in the Institute for Nuclear Studies can be made. Some of the Institute members have accepted appointments in the departments of Physics or Chemistry, thus becoming joint appointees of a department and the Institute; others have preferred to remain Institute members only.

The Institute is not a degree-conferring branch of the University; its major interest is in research at the postdoctorate level. With the understanding and approval of the department concerned, however, candidates for advanced degrees in the departments may prepare their theses under the supervision of Institute members. The thesis so prepared must, of course, meet the requirements of the department for the degree being sought.

Some of the research activities of the Institute, as described below, are supported by the Office of Naval Research of the United States Navy. Contributions to the operating expenses have also been made by the Standard Oil Company (Indiana), the Standard Oil Development Company (New Jersey), the Shell Development Company, and the Sun Oil Company. The major part of the budget is being supported by the University at the present time.

It may be appropriate to describe the Institutes as stepchildren of the Metallurgical Project, and the Argonne National Laboratory as one of its direct lineal descendants. At the request of the Atomic Energy Commission, the University is continuing to administer the Argonne National Laboratory, although its program and policies are controlled by a council chosen from a large number of Midwestern universities. In a formal sense, a member of the Institute has the same status with respect to the Argonne National Laboratory as does any scientist in the group of universities that determines its policies; namely, by mutual agreement with the Laboratory, he can carry on researches there using the chain reactors or other equipment the Laboratory can assign to his research problem. Actually, of course, owing to the propinquity of the two institutions and the fact that many of the members of both worked together on the parent war project, it has been especially easy for the Institute members to avail themselves of the privileges extended by the Argonne Laboratory.

The Institute, up to the present time, has been greatly embarrassed because of lack of space and, to a lesser extent, of equipment with which to carry out its experimental work. During this period it has been very fortunate to have had access, for several of its members, to the Argonne facilities.

The Institute, on the physics side, will, in large part, be occupied with a study of the properties of high-energy particles consisting of beta rays and photons from a 100,000,000-volt betatron, and accelerated atomic nuclei from a 350–400,000,000-volt

synchrocyclotron. Since these machines are made to produce very high-energy particles in narrow beams of high flux per unit cross section, they cannot compete with the chain reactor in the production of total fluxes of neutrons of thermal and intermediate energies. For experiments requiring the latter, the Institute will continue to request the privileges of the Argonne Laboratory.

THERE has been no attempt to organize extensive research programs within the Institute. Each member has been free to follow what seem to him interesting and promising investigations. Certain projects, such as the restoration of the Chicago cyclotron, and the development and design of the new 170-inch synchrocyclotron, have, in their very nature, required the organization of groups for carrying them out.

The restoration and improvement of the Chicago cyclotron, which was constructed in the period 1935–37 by Professor W. D. Harkins, with the assistance of Drs. R. J. Moon, H. W. Newson, A. H. Snell, and L. A. Slotin, have been prominent in the activities of the Institute. The work has been sponsored by the Office of Naval Research, under Contract ONR–21, Task Order III, and has been directed by Dr. G. Groetzinger. The technique of health protection from exposure to penetrating radiation was greatly improved during the war through the activities of the atomic-bomb project, and protection that had previously seemed adequate failed to conform to the new standards. It was necessary to discard the old water-tank shielding and replace it with 3 feet of concrete in the form of blocks that could be handled with an overhead crane. Many of the auxiliary parts of the original cyclotron had become obsolete, and replacement was necessary. The rebuilt cyclotron was put into operation during March 1947. It produces a beam of 7.5 Mev deuterons, with currents on the order of 100 microamperes. Its reliability and steadiness in operation are continually being improved.

Another Institute activity has been connected with the important radioisotope carbon 14. This long-lived radioactive form of carbon is now being artificially produced from nitrogen in the chain reactors at Oak Ridge, Tenn., and can be purchased from the Atomic Energy Commission by properly qualified scientists. Under Professor W. F. Libby, a group of Institute scientists began to look for this radiocarbon in nature, taking a hint from its artificial method of manufacture according to the reaction

$$_7N^{14} + {}_0n^1 = {}_6C^{14} + {}_1H^1 + 0.54 \text{ Mev.}$$

Physicists studying cosmic radiation have discovered the presence of a neutron component in our atmosphere. These neutrons become slowed down by repeated impact with the nuclei of the atoms of the gases of the atmosphere and eventually reach energies comparable with the kinetic energies of atoms and molecules at the temperatures of the lower part of the atmosphere. The nitrogen nuclei in the air have a greater avidity for absorbing these neutrons than do the other common constituents of the air, and thus most of the neutrons are converted into carbon 14. The newly born carbon atom, either by direct interaction with atmospheric oxygen or through intermediate compounds, forms carbon dioxide.

Since the radioactive half life of this carbon 14 is about 3,000 years, the average atom lives this long until it dissociates into nitrogen 14 and an electron:

$$_6C^{14} \rightarrow {}_7N^{14} + e^- + 0.20 \text{ Mev.}$$

The carbon 14 produced has accumulated or decayed in various parts of the earth until an equilibrium state has been attained practically everywhere in which as many carbon atoms decay in a certain time interval as appear, owing to their direct production, or diffusion, or transport to that region by convection or other means.

The carbon dioxide in our atmosphere is absorbed by the plant life on the surface of the earth or, as CO_2 dissolved in the oceans, is fixed by the life in them. Animals and men eat the plants, or eat other animals that have eaten plants, and thus the carbon 14 becomes part of our bodies and of all living things. A constant interchange with the atmospheric carbon dioxide goes on; through the deaths of animals and plants, through forest fires, and countless other processes, carbon dioxide, which was once a part of living things, returns to the atmosphere.

A corollary of the preceding discussion is that carboniferous material that has long been out of participation in the exchange between plants, animals, and the atmosphere should not contain the radioactive form, whose average life of 3,000 years is minute compared to the epochs of time in the geologic ages. Thus, carbon in petroleum or coal deposits that have been buried for untold millions of years should not be radioactive, and natural gas from deep wells, mostly consisting of methane, should consist of inert carbon.

Professor Libby obtained some mineral, or petromethane, and compared it with biomethane obtained from biological wastes in the sewage from the city of Baltimore. In order to make the test for radioactivity more sensitive, the two methanes were put through an isotope separation that concentrated the heavy carbon isotopes (carbons 13 and 14, if any) at the expense of the predominant carbon 12. The extent of the concentration could be measured by keeping track of the enrichment of carbon 13. As the enrichment of biomethane progressed, a steadily increasing radioactivity was noted, whereas with petromethane no activity above background level could be found. This interesting result gives a method of distinguishing mineral methane from methane generated in surface swamps from the decay of vegetable matter, and from biomethane in general. The thought that the carbon in an Egyptian mummy should contain less radioactivity per gram than that of tissue from a recently living animal has lead to speculation about the possibility of dating such remains from their specific activity. Frozen mammoth flesh from the finds in Siberia should indicate, by its low activity, how long ago the beast stopped participating in the carbon-dioxide cycle.

Another Institute activity, sponsored by Professor E. Teller, has been the investigation of the adequacy of the drop model of the nucleus to explain the observed fact of asymmetric fission. When a heavy nucleus of uranium, thorium, or plutonium breaks into two roughly equal parts in the process we call fission, just what parts, called fission products, will result from a given nucleus about to split cannot be foretold. If, however, we have a very large number of nuclei about to split, the fraction of this number that will split into a given set of products can be closely estimated from experiments previously carried out. Curiously enough, the symmetric mode of fission, in which the two fission-product nuclei have equal masses, is practically absent. It is very much more probable that fission products of unequal masses will result. Why this asymmetry?

It has been proposed that we try to see how many of the properties of a heavy nucleus we can predict through the type of calculation applicable to a liquid drop. The nucleons, that is, the neutrons and protons, may act somewhat like the molecules of liquid, and the mysterious forces between nucleons may have some analogue in the intermolecular forces. A kind of surface tension skin would enclose the nucleus. If such a drop nucleus is thrown into agitation by giving it excess energy, can we explain why it should split asymmetrically? A pertinent feature may be that the charged nucleons, the protons, which are concentrated

in the periphery of a spherical drop due to their mutual repulsion, would, in any perturbation of the spherical shape, run to that portion of the structure in which they could be most widely separated from each other.

The problem of calculating the result of a perturbation in the spherical shape is an extremely complex and tedious one, and was carried out by Professors Frankel and Metropolis with the aid of the ENIAC electronic computing machine built during the war for Aberdeen Proving Ground. The results indicate that the drop model, as we know it today, is inadequate to explain the observed phenomena of asymmetric fission, and that a new model, or an elaboration of the present one, will be necessary.

The Institute is also engaged in researches directed by Professor Urey on the isotopic composition of oxygen in living matter, or in the products of living matter. Normal oxygen, as in our atmosphere, is composed mostly of oxygen 16, with minute but definite amounts of oxygens 17 and 18. The theory of the fixation of oxygen by living matter in the oceans into calcium carbonate, forming the hard protective or structural constituents of many sea animals and plants, indicates that a slight variation in the composition of the oxygen is to be expected, and that this change is temperature-sensitive, so that an isotopic analysis of a shell might reveal whether the animal had lived in the warm equatorial surface waters or in the cold polar seas.

Drs. Fermi and Teller have made a theoretical investigation into the nuclear capture of negative mesons traversing matter. Since atomic nuclei have a positive charge, a negative meson is attracted and quickly bound in a quantum state, in which, for a certain fraction of the time, it moves close enough to the nucleus to be within the range of nuclear forces. According to their calculations, it should be trapped in the nucleus in a time interval very small compared to its natural radioactive mean life, about 1.6 microseconds. This behavior is quite different from that of a positive meson, which is not captured in a nucleus, but, after being slowed down by imparting energy to the electrons of the stopping material, dies a natural death after a few microseconds.

Experiments have shown, however, that disintegration particles, emitted on the order of microseconds after the stopping of the meson, are actually observed for negatives, which, according to the above argument, should have been murdered long before they could die a natural death. The discrepancy cannot be explained by any of the present meson theories, and an important revision of them, or their abandonment, seems called for.

Without attempting to list the entire gamut of Institute researches, the roster of which changes week by week, we may call attention to:

A study of the mechanism of the quenching action of organic vapors in Geiger-counter tubes.

Application of electron-multiplier tubes to nuclear research, including a search for the neutrino through the measurement of the recoil of a nucleus after beta-ray emission.

Development of a new method of mineral analysis based on radiochemistry, and application of it to a study of the composition of meteorites (the beginning of cosmic chemistry).

Attempts to verify the existence of, and to identify, if found, the positive particles that have been reported in connection with emission of negative electrons from radioactive nuclei.

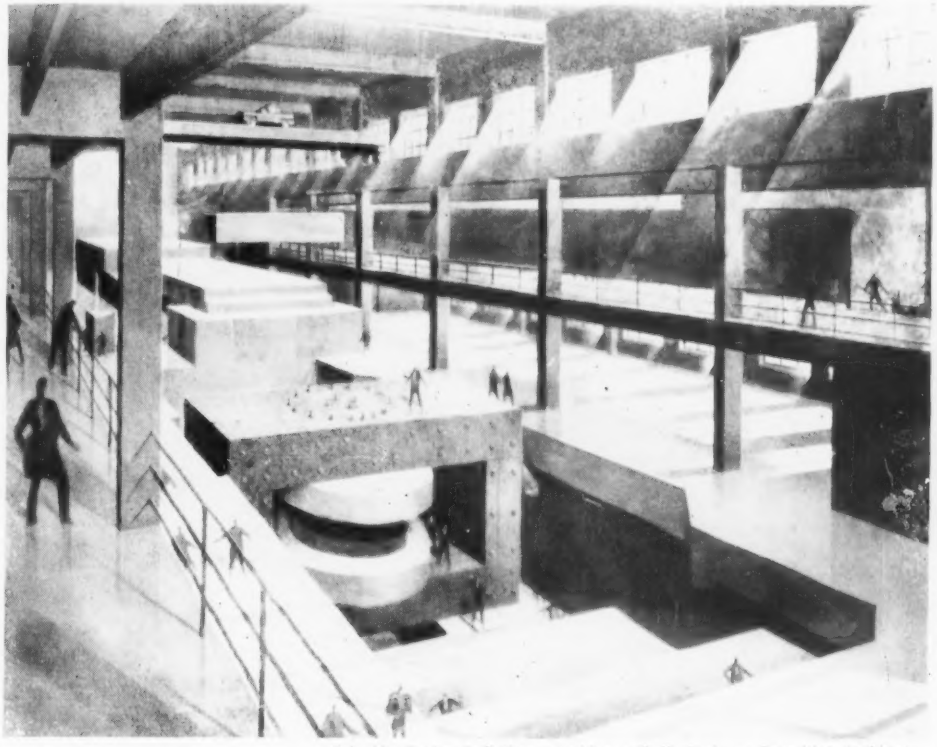
A search for emitters of alpha particles among naturally occurring "stable" nuclei.

Studies of the rarer fission products and of the chemical nature of delayed neutron emitters in fission.

Investigations of chemical reactions that follow a radioactive transformation of one of the atoms in a molecule.

A study of the magnetic susceptibilities of the ions of the salts of the heaviest elements, in aqueous solution.

A search for a possible excited state of the nucleus beryllium 7, and an attempt to measure the negative energy of binding of beryllium 8.



Schmidt, Garden & Erikson, Architects; E. B. Jackson, Consulting Architect

THE INTERIOR OF THE ACCELERATOR BUILDING

Some of the above problems may yield interesting results in a relatively short time. Others may be dropped because of technical difficulties or waning interest. Still others may be the beginning of a research program of many years' duration.

It is inconvenient to accommodate a modern program of radiochemical research in the conventional chemical laboratory, and almost impossible to use the standard physics laboratory for present-day nuclear physics. Radiochemistry needs air-conditioned counting rooms for assays of radioactivity, laboratories where remote-control operations can be carried out with the operators protected behind radiation shields, and special facilities for disposal of radioactive wastes.

The majority of the fundamental researches in nuclear physics during the next decade will probably be made with the aid of beams of very high-energy particles. Modern ion accelerators are extremely large machines with complicated electric circuits and controls. The radiation level around these machines is so high that they must be placed in concrete pens with walls as much as 8 feet thick, and the various parts of the machines have become so heavy that they must be manipulated with cranes. Such installations cannot, as a rule, be housed in ordinary university buildings.

The buildings that will be the future home of the Institute for Nuclear Studies are to be constructed as a part of the campus of the University in the block between Fifty-sixth and Fifty-seventh streets and Ellis and Ingleside avenues. The main building, consisting of laboratories and offices, will be a wing of a much larger structure that will also house the Institute for the

Study of Metals and the Institute for Radiobiology and Biophysics. The large ion accelerators will be housed in the Accelerator Building, which will be connected to, but structurally independent of, the main buildings.

The Accelerator Building is planned to house a 100,000,000-volt research betatron, a 170-inch synchrocyclotron, and the present Chicago cyclotron, probably with a new accelerating chamber permitting orbits approximately 40 inches in diameter. The building will be essentially a housing for a traveling crane, with working space beneath the crane where heavy machinery and concrete shielding blocks can be placed. The crane will have a lifting capacity of 70 tons on 2 hooks. It will have a span of about 50 feet and a run of approximately 200 feet. The accompanying drawing shows a view of the interior of the building as seen by an observer in the northeast corner of the second floor, looking down into the main part of the building through the opening in which the crane will operate. The 170-inch cyclotron is shown in its pit, which places the bottom of the magnet yoke 20 feet below the floor level of the basement, or working, floor of the building, which itself is 7 feet below ground. The pit will eventually be covered with slabs of reinforced concrete of a thickness sufficient to lower the radiation level outside to a value where it will not interfere with other experiments. Access to the pit will be provided through an elevator shaft near its northeast corner, which will communicate with the lower level of the pit through a horizontal tunnel. There will also be an entrance in the east wall directly opposite the vertical member of the magnet yoke. The control room will be located on the working floor to the east of the pit and will communicate with the pit through a winding stairway leading down to the entrance near the magnet yoke.

A concrete ledge overhangs the pit on its west, north, and east walls. Thus, when the roof beams are laid on to the full width of the bottom of the pit, this ledge will complete the radiation seal around the upper edges of the opening.

A trucking entrance from Ellis Avenue is provided for in the northeast corner of the building so that shipments of heavy units can be brought in under the crane and then lifted and transported easily to various parts of the building.

Ground was broken for the Accelerator Building on July 8, 1947. The plans for the main laboratory, which is to extend to the south of the Accelerator Building, are being detailed, and construction is expected to begin early in 1948. As the new construction begins to relieve the shortage of space, and the high-energy machines come into operation, the Institute, which is now dispersed in temporary quarters, will begin a new and better-integrated phase of its existence.

INSTITUTE FOR THE STUDY OF METALS, THE UNIVERSITY OF CHICAGO

By CYRIL STANLEY SMITH

Dr. Smith (Sc.D., M.I.T., 1926) came to this country from his native England after receiving his B.Sc. at Birmingham. In 1927 he became a research metallurgist for the American Brass Company, Waterbury, Conn., where he remained until World War II took him into special war research. He is Director of the Institute for the Study of Metals.

THE advancement of engineering science, and consequently the enhancement of the economic well-being of society, is dependent to a large extent upon the development of new, and the improvement of old, materials. Certain materials, such as plastics, have undergone spectacular improvements in recent years. On the other hand, the metal industry has little reason to be proud of its recent over-all record in producing new and better metals. A marked advance has taken place only in very specialized fields—such as ferromagnetics—fields in which intensive research will bring immediate and foreseeable profits to the sponsoring organization. More efficient power generation is dependent largely upon the development of metals that will retain their strength at higher temperatures. The introduction of lighter transport vehicles is conditioned upon enhancement of the ability of metals to withstand repeated loading, technically known as their fatigue resistance. The introduction of the lighter metals, such as magnesium, beryllium, and aluminum, can proceed only as rapidly as we are able to increase their power of resisting attack by the chemicals ever-present in the atmosphere, technically known as their corrosion resistance. These problems, as well as many others related to the performance of metal products, are being actively investigated by large groups of research workers. The lack of marked progress does not, therefore, lie in a lack of intensive effort. Rather, it lies in the almost complete absence of a science of metallurgy, a science which should be guiding the numerous research programs, and without which the programs must proceed by the laborious and costly trial-and-error method.

Several interacting factors have contributed to the retardation of the development of a science of metallurgy. Metallurgical research, and instruction in metallurgy, are expensive. As a consequence, only a few universities have departments of metallurgy, and the number of Ph.D.'s trained annually in metallurgy is very small compared with the number trained in physics or in chemistry. The majority of these metallurgists are attracted to industry. Those few that remain in universities are confronted with almost irresistible temptations to serve as consultants to industry, and their interests and energies are thereby directed away from the development of metallurgy as a science. Perhaps because of this close connection of metallurgists with industry, physicists and chemists have regarded metallurgy as an engineering subject rather than as a science, or even as a potential science. When physicists deem certain subjects in metallurgy worthy of consideration, they label these "the physics of metals"! This aloofness of physicists and chemists has acted as a barrier to their even becoming acquainted with those problems in metallurgy that would excite their scientific curiosity.

The Institute for the Study of Metals at The University of Chicago has been formed for the express purpose of developing the science of metallurgy. Attempts are being made to avoid those obstacles that in the past have retarded this development. The

members of the Institute, like most other members of the University, are under contract to receive no outside earned income. The members have, therefore, no distractions other than those arising from their own scientific curiosity. The Institute contains approximately equal numbers of metallurgists, physicists, and chemists. The mere act of bringing these three groups physically close together has engendered in each group a high esteem for the others, an esteem necessary for any true collaborative research. The personnel of the Institute numbers about sixty, of whom about a third are academic.

Since the Institute has been formed for the purpose of developing the science of metallurgy, it will not be engaged in the development of particular metals for particular purposes. Such development is regarded as belonging more appropriately to the research laboratories of the various metallurgical industries. The Institute can therefore be regarded in no manner as being in competition with these industrial research laboratories. Rather, it is intended that the results achieved by this Institute will be used by the various industries as a guide in their development of special-purpose metals. Conversely, it is anticipated that the resulting cordial relations existing between the members of the Institute and the members of industrial laboratories, and the consequent exchange of experiences, will be of substantial aid to the former in their development of a metallurgical science.

It is hoped that the Institute will be joined in its objectives by groups and isolated individuals in other universities. To further this end, the Institute invites lecturers from other universities and provides facilities for metallurgists, physicists, and chemists who might wish a leave of absence from their universities in order to work for a year within the Institute.

The Institute forms an integral part of the University, being administratively on a par with other departments within the Division of Physical Sciences. Unlike a department, however, it has no instructional responsibilities and hence does not grant degrees. Invitations may, however, be extended to its members to become members of one of the departments and thereby to assume teaching responsibilities. Thus, several members of the Institute have joined the departments of Physics and of Chemistry. Through such associations the science students become familiar with the research activities within the Institute. Because of these joint memberships, students of physics or of chemistry may do their Ph.D.-thesis work within this Institute under the guidance of one of its members.

As in a department, lines of authority among the staff members exist only in budgetary matters. Any joint research is purely on a voluntary basis. Nevertheless, each permanent member is expected to do some service work for the other members. Thus, the metallurgical group prepares specimens, the chemistry group gives analyses, and the physics group develops special instruments. Only by means of this mutual service can the individual members pursue research programs that require the combined talents of the three types of scientists. In order partially to relieve the burden of this service work, the Institute also makes professional appointments, such as professional metallurgist, etc.

In most departments it is customary for professors to seek aid from graduate students working toward degrees. The necessity of such a professor-student relationship is unfortunate. The professor gets less actual help than he would from paid assistants who remained with him over a period of years. On the other hand, the student gets so much help in his "research" that he gains no appreciation of the value of the initial planning of a program. In the Institute each research member receives as much aid as he desires in the form of

technical assistants. On the other hand, those students working in the Institute for higher degrees are under no compulsion to work upon a problem that forms part of a more general program of a staff member.

Postdoctorate fellowships are available for students from other universities who have had their training in physics, chemistry, or metallurgy. The primary purpose of these fellowships is to provide men who have already acquired a sound scientific training with an acquaintance of metallurgical problems and techniques. It is anticipated that they will form centers of metallurgical research in the universities to which they will later go.

IN ORDER that the science of metallurgy may be based upon as broad a foundation as possible, the Institute is being equipped, and specialists have been assembled, to study metals under a wide range of conditions. For studies at low temperatures a cryogenic laboratory is being built, and cryogenists have been brought from Berkeley and from Leiden. Standard equipment has been installed for studies at the highest attainable temperatures. A special laboratory is being built for studies at high pressures. The metallurgists have furnaces which turn out single crystals with the greatest ease and which, on the other hand, can prepare specimens of any grain size down to the smallest yet produced. One of the most complete X-ray laboratories has been assembled by this country's leading crystallographer. The chemical analysis group is equipped and trained for all methods of analysis—straight chemical, spectrochemical, etc. The physics rooms would remind one of an electronics laboratory if it were not for the large number of special-purpose furnaces.

It is just over two years ago that this Institute was first established. Although a considerable part of the energies of the staff has gone into routine matters of organizing laboratories, considerable progress has already been made in understanding the basic phenomena in metals, as is evidenced by the steady stream of publications from this Institute that are appearing in the scientific journals.

One inquiry being actively pursued is the search for the general laws governing grain growth. Within each grain the atoms are arranged regularly on lattice points. The orientation of the lattice planes differs, however, from grain to grain. When a specimen is heated, some grains grow in size at the expense of neighboring grains. Laws governing such growth in metals may be very similar to the laws governing the growth of foam cells.

Another program has as its objective an understanding of the mechanical properties of metals. How little is at present known may be realized from the fact that the specialists are not in agreement as to whether a perfect crystal would be very weak or very strong. The complexity of the problem may be comprehended from the fact that the strengths of some crystals may be doubled by the addition of only 0.01 percent of an alloying element, whereas that of other specimens may be greatly weakened by much smaller additions; and from the fact that specimens of the same chemical composition may have radically different mechanical properties, the specimens differing only in the mode of distribution of the different types of elements. Considerable progress has been made in differentiating the contributions to the mechanical behavior from the interior of grains and that made from the grain boundaries.

Another program relates to the thermodynamics and kinetics of the interaction of the constituent atoms in a metal. The chemistry of a solid has much in common with the chemistry of a living organism. In each, equilibrium is never attained; in each, the properties depend to a marked degree upon small traces of one constituent that

may segregate along interfaces. As an example, the addition of less than 1 percent of molybdenum to steel decreases by a factor of more than ten the rate at which carbides are precipitated during the quenching operation.

The atoms of common metals may be arranged in a lattice network of one of three types, known as body-centered cubic, face-centered cubic, and hexagonal close-pocketed. It is not known just what all the factors are that determine the particular lattice of a given metal. From a study of the differences in the vibrations of the first two types of lattice, it was suspected that lithium might undergo a slow change from one lattice type to another at low temperatures. This transformation was then looked for and found.

One of the difficulties of working at very low temperatures, say, less than 1° absolute, lies in methods of measuring how far one is from the absolute zero. A new method is being investigated in which direct use is made of the randomness of heat motion itself.

In keeping with the purpose for which the Institute for the Study of Metals was founded, it does not accept contracts to work upon special developments. Currently, a substantial part of its budget is financed by the Navy for the study of the laws governing the deformation of metals, and for a study of metals under high pressure. Several private companies have pledged substantial contributions over a period of five years, the only direct benefit they hope to receive being their freedom in discussing problems with the various members of the Institute. It is anticipated that as the work of the Institute progresses in developing the science of metallurgy, the value of such a science to industry will be so self-evident that financial support will be more widespread. Conversely, the members of the Institute recognize the nearly ideal conditions under which they work, and hence feel it their responsibility to demonstrate to the world, through their work, the wisdom of an organization in which research is carried out unfettered by controls arising from lines of authority, or by restrictions arising out of special contracts for particular work.

LEGENDS REVERSED

In making up the article "Hitching our Country to the Stars," November 1947, the Editor of the SM inadvertently switched legends of two illustrations. The instrument shown on page 373 is Hassler's 24-inch theodolite; that at the bottom of page 375 is a zenith telescope.

INSTITUTE OF RADIOBIOLOGY AND BIOPHYSICS, THE UNIVERSITY OF CHICAGO

By RAYMOND E. ZIRKLE

Dr. Zirkle (Ph.D., Missouri, 1932) is Director of the Institute of Radiobiology and Biophysics, to which post he went after a number of years as Professor of Botany at Indiana University. His chief interest is in the biological effects of neutrons, X-rays, and alpha rays.

THE INSTITUTE OF RADIOBIOLOGY AND BIOPHYSICS was created by The University of Chicago on October 1, 1945. The immediate object of its founding, like that of the slightly older Institutes for Nuclear Studies and for the Study of Metals, was to provide a continuity for basic research, need for which, in certain fields, had become painfully apparent during the prosecution of the wartime research and development projects, notably the ones dealing with nuclear energy. The Institute has been organized as an integral part of the University's Division of Biological Sciences (which includes the School of Medicine); its Director reports directly to the Dean of that Division.

The primary function of the Institute is research in the fields designated in its title. For the purposes of this discussion, radiobiology is defined as the study of biological effects of radiations—notably the high-energy, ionizing radiations such as X-rays and fast neutrons—and biophysics is defined as the study of the physical structure and functions of biological objects—a very broad field which probably cannot be fully covered by an organization of wieldy size. In addition to the primary function of research, the Institute takes part to a certain extent in instruction, cooperates with other members of the faculty in various research activities, and devotes a substantial fraction of its manpower and facilities to providing technical services to faculty members outside the Institute.

The staff consists of individuals trained in diverse fields of the biological and physical sciences. This diversity makes it possible for the members to form suitable teams for attack on specific problems. Sometimes the teams include members from other University organizations. The staff includes not only faculty members, but nonacademic persons of professional grade.

Some research activities are not yet in progress because Professors Brues, Rose, and Shonka are currently on leave of absence to Argonne National Laboratory. The programs underway are mainly:

Biophysics of nerve (Cole, Marmont, Ferreira), with special reference to the electrical properties of the nerve impulse.

Studies on metabolic processes (Bloch, Abrams), emphasizing syntheses and featuring isotope-tracer techniques.

Studies on biological effects of radiations (Zirkle, Bloom, Boche, Ting), with chief emphasis on the mechanisms of various biological actions.

The physics of macromolecules (Szilard, Novick), specifically the nature of induced mutations in microorganisms.

Studies on localization of radioisotopes in normal and neoplastic tissues (Moon, Szilard, and members of the School of Medicine).

Mathematical analyses of experimental data and of experimental planning (Savage).

The Institute is temporarily housed in two buildings; the headquarters and part of the laboratories are at 6200 Drexel Avenue, and the remainder of the laboratories are at 6125 University Avenue. Each of these sites is about three-quarters of a mile from the middle of the campus; communications are maintained by automobile. The Institute is ultimately to share new buildings with the Institute for Nuclear Studies and the Institute for the Study of Metals. These buildings are to be on the campus in the

block bounded by Fifty-sixth and Fifty-seventh streets and Ellis and Ingleside avenues. The Accelerator Building is now under construction, and the remainder are in the blueprint stage [see page 487].

Major equipment now on hand includes extensive electronic implementation, especially for the work in nerve biophysics; numerous counters and accessories for assay of radioisotopes; two 250-kilovolt X-ray outfits, one designed primarily for irradiation of biological objects, the other for physical measurements and calibrations. A mass spectrometer for work with stable isotopes is under construction. The present University cyclotron, which produces 8 Mev deuterons, is available to Institute members for fast neutron irradiations and production of certain radioisotopes. Various other sources of radiations are available nearby in Argonne National Laboratory. When their construction is completed, the large betatron and the synchrocyclotron will furnish very high-energy X-rays, electrons, neutrons, and light atomic nuclei, all of which are of great radiobiological interest.

The Institute has an electronics development laboratory (Norris), a drafting and design group (Cross, Packard, Soderquist), and a well-equipped convenience shop staffed by two full-time machinists. Large jobs of equipment construction are carried out in the University's Central Shops, under the supervision of Mr. T. J. O'Donnell. Glass work is done in the Central Glass Shop in charge of Mr. C. C. Van Hespen.

The Institute, being a research organization, does not recommend students for degrees or provide curricula leading to degrees. However, a curriculum leading to the Ph.D. in biophysics has been set up in the Division of Biological Sciences under the administration of a Committee on Instruction in Biophysics. This Committee is composed of members of the faculties of the Division of Physical Sciences and the Division of Biological Sciences. The curriculum includes basic and advanced studies in both the physical and biological sciences and research for the Ph.D. dissertation. Each student's research is done under the supervision of any suitable faculty member, who, if not a member of the Committee, works with it in supervising the student's progress.

Because of its facilities and the emphasis on research, the Institute offers a favorable environment for postdoctoral training. It also offers formal courses in certain of its specialties that are not covered by the offerings of the regular teaching departments. For instance, the Institute is currently sponsoring, and furnishing a large share of the teaching staff for, a six months', full-time curriculum in radiation hazards, which is especially designed for medical officers in various government services.

OTIS WILLIAM CALDWELL, 1869–1947

By FRANCIS D. CURTIS

School of Education, University of Michigan

OTIS WILLIAM CALDWELL was born on December 18, 1869, in Lebanon, Ind. His parents were Theodore Robert and Belle C. Caldwell, prosperous farmers near Lebanon. His early years were spent on his parents' farm, where he received the upbringing and schooling typical of the country boy of his time. In 1894 he was graduated from Franklin (Ind.) College with the B.S. degree; four years later he received the Ph.D. in botany from The University of Chicago.

Dr. Caldwell's career as a college teacher began in 1899 when he accepted a professorship of botany in Eastern Illinois State Normal School. His activity in research, publication, and in the work of many scientific organizations soon brought him to the attention of other institutions of learning, with the result that in 1907 he accepted an invitation to join the staff of The University of Chicago. From 1913 to 1917 he was Professor of Botany and Dean of the University College. During this early period Dr. Caldwell gave his major attention to teaching and research in botany, earning for himself a permanent place among the country's outstanding botanists. In 1917, in recognition of the commanding position he had attained among scientists, his alma mater conferred upon him an honorary LL.D.

Although primarily a scientist, Dr. Caldwell excelled also as an educator. His great interest in classroom teaching and the training of teachers led him, in 1917, to resign his position at Chicago in order to accept a professorship in Columbia University, where he was to institute and administer the Lincoln Experimental School. He held this position until 1927. To the arduous duties of this important post he added those of administering the Division of School Experimentation. When, in 1933, he retired from the Columbia staff, he became Emeritus Professor of Education.

Dr. Caldwell's teaching was by no means limited to the institutions where he held regular appointments. In 1904 he taught in the University of Indiana Summer School of Biology; in the summer of 1931 he was a Visiting Professor at the University of California. Here he added substantially to his already great reputation as a distinguished lecturer by presenting a series of lectures on scientific subjects as a special feature of the summer session. He spent the year 1937–38 at Atlanta University, where he devoted his attention to the successful establishment of graduate work in education.

Dr. Caldwell was a prodigious worker. The huge quantity of his literary output is explained by the simple statement he once made to a close friend: "Hard work is no hardship. I *like* to work!" Few authors can approach in number and in variety of subject matter the list of books of which he was either sole or collaborating author. He published the first of a series of botanical textbooks and manuals in 1901. The last of these, *Introduction to Botany*, published in 1914, after many mutually pleasant and profitable years of authorship association with Professor J. Y. Bergen, is still a standard textbook in elementary plant study. Caldwell and Eikenberry's *Elements of General Science*, with its revisions, probably exerted a stronger influence in molding the subsequent development of general science than any other factor. In 1923, when textbooks of science written especially for junior-high-school students were practically unknown, Dr. Caldwell wrote *Open Doors to*

P. Stephens, Inc.

OTIS WILLIAM CALDWELL, 1869–1947

FROM 1913 TO 1917 HE WAS PROFESSOR OF BOTANY AND DEAN OF CHICAGO'S UNIVERSITY COLLEGE.

Science for them. Subsequently, he prepared a highly successful series of textbooks in general science and biology for secondary schools. His great versatility is evidenced by his publication (either alone or in collaboration with others), during his amazingly prolific years, of *Biological Foundations of Education*, a book of outstanding value to all teachers of biology and education; *Then and Now in Education*, a comparison of important educational trends and movements; *Do You Believe It?* a popular study of unfounded beliefs; and *Science Remaking the World*, a presentation of milestones of scientific research. Hundreds of his articles appeared in scientific and educational journals.

Because of his stature as a leader in the teaching of science, Dr. Caldwell served on many important committees. Prominent among them were the A.A.A.S. Committee on the Place of Science in Education, of which he was Chairman from 1924 until his death; and the Forty-sixth Yearbook Committee of the National Society for the Study of Education. In the recent report of that committee he was an active collaborator and the author of the only signed chapter, the final one: A Look Ahead: Science Education Imperative.

The great regard in which leaders in the fields of science and education held the scholarship of Dr. Caldwell is abundantly shown by his membership in Sigma Xi; his Fellowship in, and General Secretaryship of,

the American Association for the Advancement of Science, which latter position he held from 1933 until his death; his "starred" rating in *American Men of Science;* and his memberships in various educational societies. After his death on July 5 a prominent journal stated: "The death of Dr. Otis W. Caldwell . . . has ended a notable career in science and education." A distinguished educator and former colleague of Dr. Caldwell paid him this tribute: "The passing of this man marks the end of an era in science education."

But it was his other, more human qualities —his friendliness and his cordial interest in those with whom he came in contact—that, combined with his capacity for scholarship, made him a great leader. One of his associates of nearly fifty years ago designates him as "a delightful and genial companion and true friend . . . most successful and stimulating teacher, greatly beloved and respected by his students." At every educational gathering he attended he was sought out by crowds of friends, former colleagues, and students, eager to exchange greetings with him. He was esteemed, too, by his townspeople, few of whom realized the eminence of this modest and unassuming man, but many of whom loved him as a friend.

Dr. Caldwell was professionally active almost to the day of his death. Until nearly the end his plans were buoyantly for the future. His passing is an irreparable loss.

THREE QUESTIONS

"Is truth ever barren? . . . Will it not raise man's mind above the confusion of things? Shall he be able thereby to produce worthy effects and to endow his life with infinite commodities?"—Francis Bacon, 1561–1626.

Three hundred years and more have come and gone
Since Bacon's busy pen and curious mind
These questions to the centuries consigned;
How reads our answer, if there should be one?
Truth is not barren, benefits have flowed,
At first a trickle, then a torrent broad
From springs and wells of science; all applaud
Her gifts and gains, so lavishly bestowed.

But is man's mind above confusion raised?
How stands the audit of his aims and life?
Worthy effects are by but few appraised.
The many listen to the siren's song
Of greed and ease, or wake to sterile strife
While Bacon's vision waits, how long! how long!

THOMSON KING

SCIENCE, EDUCATION, AND THE FUTURE OF MAN*

By A. J. CARLSON

A former President of the A.A.A.S., Dr. Carlson (Ph.D., Stanford, 1902) is so well and so widely known as to make a biographical note almost superfluous. He has been at The University of Chicago since 1904 and was chairman of the Department of Physiology from 1916 until 1940, when he became emeritus professor. The list of his honors, his travels, and his accomplishments is much too long to include here. Born in Svarteborg, Sweden, in 1875, Dr. Carlson still retains a piquant suggestion of Swedish accent.

WHAT factors shaped the human biologic and social evolution of the past—say, the past million years? We are familiar with the term and the idea of the survival of the fittest. It is a fact that all animal species, man included, tend to reproduce in any and all parts of the world to a point where the supply of available food becomes insufficient to meet optimum nutrition requirements, except as the increase in number of a species is checked by disease and by violence from within and without the animal species itself. Past evolution of man has accordingly been determined by factors still operating among wild animal species. Understanding of man and nature played no part, because man had no such understanding either of himself or of nature until practically yesterday. Science has now given us a great deal of reliable information on the nature of man, the factors of health and disease, and the nature of the universe about us. The question is, Can this understanding of man and nature modify, ameliorate, and improve on the crude, blind, and, we might say, cruel factors that determined past human evolution?

This important and very serious question dawned gradually on my thinking, stimulated largely by two experiences:

(*a*) We are now seriously concerned with the possibility of wreckage of our civilization by war and atomic bombs. It is a fact, so far as we can rely on history, that every human civilization of the past has "gone with the wind," even without the aid of atomic bombs. Was there anything in these temporary civilizations of the past—Asiatic, European, and American—that weakened the human frame, rendered man less able to survive? This question is at least as important as "Shall we, or shall we not, use the atomic bomb in our warfare tomorrow?" It deserves attention. I do not have the answer. Dr. E. A. Hooton, the Harvard University anthropologist, thinks he has the answer. I quote from Dr. Hooton's *Twilight of Man* (p. 192):

> Material prosperity encourages the preservation, pampering, and reproduction of the biologically inferior elements which are parasitical upon rich civilizations. Then some cleaner-blooded, and culturally crude stock crashes in and wipes clean the slate. Out of apparent evil comes eventual good, because the cultural and biological dross is destroyed so that man and civilization can rebuild themselves. Evolution, if it is to be progressive, demands the selection of the unfit and the culturally obsolete for extirpation. We can either prune off our own rotten brances or submit to a ruthless cutting down and thinning out by more vigorous conquering stocks.

This factor, stressed by Dr. Hooton as the cause of past failures of so-called civilizations, may be one element in some cases. I do not think it is the complete answer. In Rome two thousand years ago the slogan was "Bread and circuses." In our own country today some fellow-citizens insist on the slogan "Security from the cradle to the grave." Both slogans are unsound biology.

* From an address delivered at the inauguaration of President Stoddard, of the University of Illinois, May 15–16, 1947.

Both are off the beam, as I understand man, past and present.

(*b*) On a visit to China some twelve years ago, I was brought face to face with two biologic incompatibles among the two hundred million people in northern China. One of these was the extensive undernutrition of many of the people, owing to the inability to raise sufficient food for the two hundred million mouths and stomachs. This situation exists despite the care of the land as indicated by fair crops, even after ten or twenty thousand years of agriculture; that is to say, the Chinese farmers have not decreased the fertility of the soil as fast in those thousands of years as we here in the United States have done in the past two hundred years. The second incompatible was this: So far as we have reliable vital statistics on northern China, the infant mortality among these two hundred million people is very, very high. I was told during my visit that one out of every two infants born in northern China died during the first year of life. This is a terrific waste. There is no question but that application of the principles of modern medicine in northern China would reduce this terrific infant mortality, this terrific waste, to the figures in those lands where modern medical science prevails. But suppose this modern medical science becomes available in northern China and these millions of infants are prevented from dying? All that means just more mouths facing starvation. This does not add up. I cannot conceive of a moratorium on advance in medicine and the control of infectious and epidemic diseases in all lands. But these diseases were important elements in eliminating the unfit or the less fit of our race during the past million years. What is to take the place of disease in human evolution tomorrow? Is it to be more war or more intelligence? I, for one, cannot see that breeding like rabbits is necessarily indicative of our name, *Homo sapiens*. We know now enough about defective hereditary factors in man to eliminate many tragedies and calamities, if we have the vision and the courage. As I look at it, to bring children into this world, children impaired physically or mentally through defective heredity, is cruelty to children. I go our late Chief Justice Holmes one better: I insist that three generations of imbeciles are more than enough.

ARE we handling our soil, air, water, and other natural resources in the interest not only of today but of posterity, a hundred thousand years ahead? Ultimately, the healthfulness of our air and water and the foods produced on our soil and in the sea will determine our number, if not our health, our efficiency, and our happiness. We have, at long last, begun to think of soil conservation, even in my own state of Illinois. In the *Chicago Daily News* of November 11, 1946, there appeared an editorial under the heading "We Must Eat." This editorial discussed a meeting called by the bankers of Illinois to consider the impairment of farm land values in our state by failure to retain or restore fertility, and the investment losses of the banks through such deterioration of the land. I quote this statement from the editorial (without vouching for its accuracy): "Unsound commercial farming in the past has destroyed over 250,000,000 acres of American crop lands." John Fischer tells us (*Harper's Magazine*, May 1947) that

> Most Americans do not yet realize the ruinous speed with which we are stripping away our timber, our strategic minerals, our natural gas and oil, and the very earth itself. . . . This is no longer of interest only to a few wild-life enthusiasts and soil scientists; it has become a question of survival.

Chancellor Hutchins thinks that another hundred years of this thoughtless waste spells the end of our civilization. In a recent number of the *Daily Iowan* (Iowa City) there is a thoughtful editorial under the caption "They Can't Eat Guns," from which I quote: "Common sense tells us that

it would be a lot easier to sell democracy between two slices of bread than between two thicknesses of armor."

I lived on a farm until I was sixteen, and I have been around (with my eyes open) in many parts of the world in my more than seventy years. It took probably more than thirty to fifty thousand years to produce the fertile soil of Illinois, Ohio, Iowa, and Kansas. Now we have ruined tens of thousands of acres of fertile soil in three of these states by surface mining, to get out a few tons of soft coal for a few dollars per acre at the sacrifice of good crops for the next fifty thousand or hundred thousand years. Does that mean that we are looking ahead, that we are thinking of our children's children? In the face of this can we claim the name *Homo sapiens?* Man—that is, the human race—has dwelt on this earth at least a million years. It seems to me it is high time that those who would be wise should look ahead at the possible consequences of their individual, national, and international actions, not only today and tomorrow, but a hundred, a thousand, a hundred thousand years from now. As I see it, the person who has developed some control of his greed, his vanity, and his fears; who has developed to the limit of his brain the understanding of man and the universe achieved by science; who thinks in terms of his fellow-men—the human race—not for today, tomorrow, or even the next hundred years, but for a future at least as long as our human past; and who at the same time uses all his influence, without violence or coercion, to prevail on his fellow-men to follow his example—that man only is entitled to the designation "wise."

The minerals and other essential elements removed from the land with the food crops must obviously in the long run be replaced, unless we want to produce a desert. We are not doing this replacement adequately at present. I have seen American tourists, even college graduates, turn up their noses in derision and scorn at the farmers in France and Holland who took care to get the night soil back on the land. We are proud of our hybrid corn and the higher yield per acre of this product, but we have this higher yield at a period when it is not absolutely necessary for food and health of man or beast; and unless we replace the soil elements removed at the greater rate with the higher corn yield, we shall simply deplete our soil that much faster. India and China cannot now produce enough food for their seven hundred million people. Sir John Orr, Director General of the Food and Agriculture Organization of the United Nations, thinks that we must double the world's food production if the two and one-quarter billion people in the world are to enjoy an adequate diet. If we could do that—if we did that—what then? According to past records, increasing the food supply by better agriculture merely yields a parallel human population increase. England and Belgium must import much food to meet the needs of their people. The United States, Argentina, Canada, and Australia will soon have no food to export, however, unless the growth of the population is checked by war, disease, or the exercise of intelligence. The local populations will need all the food each of these countries can produce. Must we, then, fall back on the blind agencies of the jungle, disease and violence? Why not give understanding and intelligence a trial?

Modern industry is literally turning the earth inside out at a rate that never occurred in the past, except in the neighborhood of volcanoes. Modern industry is thus changing man's environment at a faster rate than ever before. Are any or all of these changes beneficial, indifferent, or injurious? It is true enough that adding lead to gasoline produces a mixture that keeps automobile engines from knocking. It is also true that the amount of lead thus spewed into the air, into the countryside, and into our streets, alleys, and homes is not enough as

yet to produce acute or chronic lead poisoning. But suppose we continue with leaded gasoline for another five hundred years, what is going to happen? That lead thrown into the air of country and city from the automobile exhaust does not disappear, it becomes part of the soil, the dust, and the water. And this is not the only source of lead thrown into our environment by modern industry. Lead arsenate is a good killer of insect parasites on our fruits and vegetables. The question is, In the long run will a worm in the apple be more injurious to human health than lead and arsenic on the surface of the apple? And there is some evidence that spraying with lead arsenate for as short a period as thirty years may seriously poison the soil for some vegetation. Similar problems face us tomorrow in connection with fluorine; that is, the increased use of fluorine in industry and the exposure of man, animals, soils, water, and air to this element. For, remember, when we drive off part of the fluorine in our rock phosphate for the soil, that fluorine is not driven into space, it remains on the earth as part of the human environment.

I, for one, will not be happy to contemplate war and violence replacing tomorrow the factors of disease and epidemics in limiting the human race on this earth. To be sure, war, with the aid of science, is gradually becoming a more effective killer and maimer of man. According to the recent estimates of the Harvard University professor H. M. Jones (*Education and World Tragedy*, 1946, pp. 7–9), in the first three decades of the present century, we killed by war 33 percent more people than were killed by war in the previous eight hundred years. Professor Jones asserts that if the entire population of the United States were wiped out tomorrow, this number of dead would be less than the number of people killed by war during the past half-century. But this wholesale killing of men by war may not reduce the pressure of overpopulation, because of the damage to man's biologic and physical environment from atomic bombs and biologic warfare.

As I view man in history, war is one of the most stupid of his activities. I am reminded of the highway signs put out in northern Michigan, Wisconsin, Minnesota, the Dakotas, Washington, and Oregon by the U. S. Forestry Service forty years ago. These signs read:

EVERYBODY LOSES WHEN
FORESTS BURN

This applies to war. Everybody loses in war. No, war is not the answer. In this war (for we have not yet won the peace) we selected 60 percent of the ablest, healthiest, and most intelligent of our youths and trained them to kill or maim and to be killed or maimed. If a farmer selected 60 percent of his finest horses, cows, sheep, and hogs and forced them to be killed or maimed for no purpose, I think we would not call that farmer a wise man. Stopping medical progress and medical service is not the answer for our race tomorrow. We have the answer, at least in part, on the basis of present knowledge of man and the universe, both as to human reproduction and as to the care of the soil, water, and air. From all the evidence now available, it seems clear that in the past greed, guile, and violence had some survival value for primitive man. Assuming that these drives can be curbed on a national or international scale by new mores based on understanding, reason, and emerging justice, will the latter have equal survival value in and for the kind of society we hope to build? My answer is, Yes. But we must apply new and different measures to reduce the number of the least fit. We have enough scientific information to make a beginning in that direction now. Unless reason based on understanding effectively guides social evolution of tomorrow in the direction of elimination or reduction in number of the least fit—those who cannot

or will not strive for the individual and the common good—I see no escape from the degeneration that invariably follows biologic parasitism.

Assuming increasing control of infectious diseases, a decrease in the prevalence of war, and a not-too-rapid weakening of the human race by the reproduction and survival of the less fit, it seems clear that food will some day be the limiting factor of our numbers, if not of our health and efficiency, no matter how much more understanding we may gain of the interior of the earth, of subatomic energy, and of the supergalaxies in the distant heavens. That means that agriculture and foods are clearly must items in general education tomorrow. But why wait till tomorrow?

It seems clear that the answer to my more than $64 question is not to be found in the current three-R's curriculum of our schools nor in the "great books" of the past. Science itself has not yet given the answer, unless the answer lies partly in the evidence that the cerebral cortex, the latest addition to the human brain, has not yet acquired complete control over the ancient hypothalamus, the part of the brain that we have in common with the toad, the snake, the hyena, and the goat. But, if it is true that a man's social responsibility parallels his understanding of man and nature, the scientist and the educator are certainly on the spot, facing this question. Whether science and the scientific method, whether understanding, honesty, reason, and justice can through education contrive survival values equal, if not superior, to the blind forces of nature that shaped man's past, is as yet in the laps of the gods. Still, we cannot deny the possibility, and we shall nurse the hope that the hairy ape who somehow lost his tail, grew a brain worth having, built speech and song out of a hiss and a roar, and stepped out of the cave to explore and master the universe may someday conquer his own ignorance and irrational behavior.

There is some evidence that the dominance of emotions over reason and understanding in man may be due to functional rather than to structural brain factors. If this is the case, we may get somewhere with better general education. At least, we cannot lose anything by exploring this possibility. But whether we do or we don't, the educator, the teacher, is still on the spot. On the science sector, a course in the history of science as a part of general education, proposed by President Conant, of Harvard University (*On Understanding Science.* New Haven: Yale Univ., 1947), will be better than no science, but I do not think this or any other history course will adequately meet our needs. I think we must get closer to the grass roots of science, even in general education. Knowing man and the processes of learning and effective conditioning as I do, I believe that listening, seeing, and reading, must be supplemented by at least a minimum of doing. And when I speak of general education, I cannot conceive that training all our healthy youths in the art of killing and maiming their fellowmen is a wise element in such education either for today or for tomorrow.

The questions I have raised have no ready or easy answers. The picture I have outlined, though dark and sobering, squares with known and proved facts, I think. As I see it, there can still be better days ahead for man, if we think ahead, if we go to work and apply the understanding of man and nature given us by science. It seems clear that, in the long run, the practices of the jungle will not work for the best interests of a species provided with the human cerebrum. For it is easier to wreck than to build.

We hear much today about "One World," but not enough about "One Human Species." At least we do not always act, at home or abroad, as if we believed this proved biologic fact. Although the primary challenge of our sobering problems is to educators and scientists, the responsibility must be shared by all sane citizens.

THE COMPLEAT ANTIVIVISECTIONIST

By HELEN MacGILL HUGHES

Mrs. Hughes (Ph.D., Chicago, 1937) is Assistant Editor of the American Journal of Sociology, *oldest and largest journal in its field. She is also a part-time correspondent for* Time, *covering medical, scientific, and educational news. She is, besides, the wife of the sociologist Everett C. Hughes (University of Chicago) and the mother of two small children.*

A RECURRENT threat to any scientist whose work calls for animal experimentation is the zeal of the antivivisectionists. Some biologists have for years energetically fought them off, but there are many who have paid little heed to the campaign. Yet even among those most active in the fray there seems to be very little comprehension of the mentality of the antivivisectionist. It can be isolated and dissected by case study.

Three years ago a dramatic battle was fought in the City Council of Chicago over a dog pound ordinance. The vigilance of Dr. Anton J. Carlson, Dr. Arno Luckhardt, Dr. Carlos Reed, and others brought this to the attention of their colleagues elsewhere at the time; it is perhaps the best known of their many skirmishes. Though it is now only an incident in a conflict that has gone on for nearly a century, it is logically so like many such encounters in other places and at other, more recent dates that I shall treat this local campaign as representative.

As the city ordinance stood in 1944, a stray dog could be reclaimed at the Chicago pound upon payment of a dog license fee and the animal's board; it usually cost a little more than $8.00 to get back a lost dog. Unclaimed unlicensed dogs were either destroyed or released to one of the city's four medical schools at no charge. During 1943 the medical schools had been allotted 9,000 dogs—a number actually not sufficient for the war-connected research on malaria, shock and hemorrhage, and the like. And no school was in a position to pay for animals should the free supply be cut off. Meanwhile, the humane societies were destroying 18,000–28,000 dogs a year, many of which might have been useful as laboratory animals. The cause of the passage at arms in 1944 was a proposal in the City Council to amend the pound ordinance so as to lower reclamation charges to owners, stop the supply of dogs to laboratories, and put the administration of the pound in the hands of humane-society officers.

For months the Hearst paper in Chicago, the *Herald-American*, crusaded for the amendment; for Mr. Hearst, himself a convinced antivivisectionist, has made his papers, in whatever city they are located, the public vehicle of antivivisectionist sentiment. Consequently, it is an instructive exercise for scholars to read the Hearst editorials—even more so the Letters to the Editor—for they expose to the academic man as possibly nothing else can, the mind of his enemy. At the time of the great Chicago battle, the *Herald-American*, as the self-appointed organ of the antivivisectionists, made the issue of major importance in its columns. Readers were constantly exhorted: "Write to your alderman—and here is his name and address." The other papers in the city—the papers read by academic, professional, and business people—gave the matter notice whenever there was any news to report, doing so in a matter-of-fact way that gave little more than a hint of the dimensions of the sound and fury. Late in the summer the amendment was presented to the City Council. The hearings were riotous. The deans of the medical schools and other notable research

men attended one session with 1,500 of the city's medical students (most of whom were in Army or Navy uniform at the time), to protest any limiting of the supply of animals to laboratories. "Not in recent years," reported the *Herald-American*, "has Chicago witnessed such a turn-out of the propaganda forces of organized medicine, fighting desperately to keep the privilege of removing family pets from the city dog pound for dog torture experiments." The opposition, also out in force, brought forward a veteran of seventy-six bombing missions, who took the stand to declare that "the kids back home had a right to ask protection for his pet and that was one of the things he was fighting for." A performing dog was introduced into the Council Chamber and put through his paces.

A compromise amendment was eventually passed that lowered dog license fees and pound charges to owners reclaiming dogs and, at the same time, permitted the university laboratories to acquire unclaimed dogs under the supervision of a citizens' board. Some of the members of this board, who appear to neither slumber nor sleep, are vigorously exploiting its nuisance value; each time the board charges a school with neglect of its dog quarters, the fate of a whole research program hangs in the balance. The schools have always been able to clear themselves, however.

AN IMPORTANT wing of the antivivisectionist movement is composed of people who have joined because they shrink from suffering. The prejudice against surgical procedures is an old one whose roots are probably in the medieval religious taboos against the mutilation of bodies. The sentiment was certainly understandable in the days before modern anesthesia, and it was then that the antivivisection movement had its beginnings, in England. Spokesmen of the movement insist that even today, however, dogs are operated on while conscious. "If the dog is not awake," asked one of them rhetorically, "what can the experimenters learn about his reactions?" And so the humane societies prefer to kill animals themselves rather than permit them to be assigned to laboratories.

In its insistence on the cruelty of research, the Hearst press has developed a dramatic glossary, in which "medical butcher" and "dog torturer" are synonymous with laboratory researcher; a laboratory is a "torture chamber;" any experiment at all, whether it be the injection of hormones or the feeding of vitamin pills, is "vivisection" or "dog torture;" and every unlicensed stray dog, "the family pet."

> Begin "The Chicago Chamber of Horrors" [ran a promotion squib], by a man who spent several months in a vivisection laboratory in this city. The abuses he has witnessed seared his soul. If you have any spark of humanity in your heart you will want to read "The Chicago Chamber of Horrors." Begin it Friday in the *Chicago Herald-American*.

This bloody chronicle, complete with "artist's drawings," turned out to be an account of doings in the Department of Surgery of the University of Chicago Medical School. Those were days when the school's astonished faculty could hardly wait for the paper to come out.

The language of this literature is violent because it is a recruiting talk, not an account of the day's news. But such appeals, though fanatically phrased, attract to the movement against research large numbers of tenderhearted readers. These become the moderates in the organization, the people who may never go to meetings but who will write checks for what appears to them to be a worthy cause. Dr. Luckhardt tells the story of a physician friend of his who was giving insulin to a small child. "Doctor," said the patient's mother, "I am writing my will and I have some money to bequeath to some good cause. I have been thinking about the antivivisection societies. What do you think of them?" To such a woman a

sick child is surely as moving as a sick puppy. That she should be so woefully misled as to think of subsidizing an organization that would have made the discovery of insulin impossible is not entirely her fault. For the puppy's protagonist is free to exploit the public prints in his behalf. Scientists, on the other hand, in appealing to the layman, are restrained by a characteristic fear and distrust of publicity. This makes it an unequal contest. But it does not need to be so. And, if they can contrive to escape this dilemma, the scientists can be confident of a fair chance to win over the more moderate fraction of the antivivisectionists. They might do worse than avail themselves of the strategy outlined several years ago by Mr. Hearst, who, it must be admitted, has a devilishly sure touch in manipulating the public. After the defeat of the Burdick Bill to abolish animal experimentation in Washington, D. C., he advised new tactics: "Don't have paid officials and costly quarters. Meet at home for tea, luncheon, or card parties. Begin in the neighborhoods as though you were getting up an outing club. Raise small funds and great personal interest. Appreciate your friends in the state legislature." This is a forewarning that the campaign will be marked by intense local enthusiasm rather than by impersonal national operations. And it calls for personal forcefulness and energy in the defense.

No one can doubt that there are many honest, sincere people in the movement, but, like most movements, it has its lunatic fringe, or, more accurately, its lunatic core, and this is the part most often and most vociferously heard from. It is noisy, inaccurate, illogical, and ignorant. It represents animal experimentation as reckless, needless slaughter on a heroic scale. A Dr. William Held, ignoring the fact that Sir Frederick Banting developed insulin at a sacrifice of just thirty dogs—a fact he must have known if he is, indeed, the "internationally famous Chicago physician" he is described as being—declared:

> Diabetes research learned nothing from dogs, as it is not the same disease in man. Cancer research is not helped by vivisection, as it is not the same in man and animals. . . . Harvey found the circulation of the blood by observing healthy human subjects. . . . The step from animal to human vivisection is an easy one to the overenthusiastic researcher.

Much that is puzzling in the statements of the fanatics in the movement is made clear once the unstated major premise is grasped: namely, that a dog has the same moral value as a human being. If a dog is the equivalent of a man, then there is something at best unsporting, at worst callously selfish, in compelling the weaker creature to suffer in order that the stronger may be spared. "I would give my own body," cried a popular preacher who is an antivivisectionist spokesman in Chicago, "but I would not take advantage of a stray dog." Asked: "But if the facts learned from the study of a dog would save your child?" the answer is, logically enough: "Experiment on me. Or on rats, guinea pigs, or rabbits." It is probably a historical accident that cats, guinea pigs, monkeys, white rats, and hamsters are not assimilated in the antivivisectionist's conception of humanity. When Dr. Carlson asked a leader of the movement how she could bear to wear a fur coat or a feather in her hat, considering the suffering that must have been engendered, she replied, "I do not make pets of mink, squirrel, and pheasant."

The investing of a dog with a man's value explains the curious fact that, though they actually play the role of champions for animals as against those who would put man and his afflictions first, the antivivisectionists describe themselves as "humanitarians." This only adds to the semantic confusion occasioned by their appropriating the term "dog lovers" to denote themselves exclusively—though they some-

times demonstrate the perversity of physiologists by pointing out that the latter, too, have family pets. The result is to expose a group of scientists, already conceived of as cruel and powerful, as also just plain stupid and selfish.

In this eccentric phraseology a whole complex of sentiments is ventilated. In the Hearst papers, research men are often referred to as "the Bourbons of medicine" and the "Vivisection Bund." The presumed wealth, arrogance, and power of doctors is a persistent motif. "The pound," said a Chicago leader, "belongs to the people, not to any group. Why do doctors have access to impounded dogs? Lawyers can't go to our library and take out books for keeps." When the compromise amendment was passed, an editorial in the Hearst paper called it "... a triumph of human sympathy over entrenched conceit, tenderness over arrogance." This contrast between the plain, decent citizen who has no influence and the rich, potent member of a self-seeking, well-organized profession is a common and popular theme in mass publications. Mr. Hearst himself employed it when, in a column he supplied his own newspapers, he wrote about a dog who was flown to California to see his master, who had had to leave him to join the Army. The dog, he reported, had refused food since his master's departure and was kept alive during the journey by heart stimulants. On arrival the plane was met by "sentimentalists—a platoon of soldiers, a major and a colonel and unlimited lieutenants." "Are we," continued Hearst, "sentimentalists or sadists or saps?"

THIS depiction of the matter, with its social implications, wins for antivivisectionism a variety of people who are not so much interested in dogs as they are motivated by economic and political unrest. What they really hate is doctors, or scientists in general, or city life, or the modern world. A recent study of the Prohibition movement reveals that one element in it is a harking back to old days of simple rustic virtues, idealized as in Goldsmith's *Deserted Village*. The antivivisectionist might, with a small change in his circumstances, be instead a fanatical persecutor of Jews, a convinced Dry, an adherent of any social Utopian movement. Thus, the 1948 presidential candidate of the American Vegetarian Party observes that he hopes to have the votes of the vegetarians, prohibitionists, antivivisectionists, anticigaret groups, "and other people of similar high moral principle." The common quality among all these is that they are Utopians of a sort: people who quarrel with the moral code of the rest of the world and who seek to reconstruct society, beginning at some point of difference which may seem trifling but which in reality has deep significance in their eyes as the symbol of the great gulf fixed between this sinful, foolish world and a more perfect social order.

There may be many who happen to swallow the antivivisectionist bait—and not some other—because their friends have done so, or because the Hearst paper brings it to the breakfast table. That is not to say they are insincere; it is to locate as the root of their conviction, not an unrestrained sentiment for animals, but a basic uneasiness in modern life. For the antivivisectionist of the extreme sort is a moral revolutionary, a sectarian. Perhaps the sectarian mentality has never been better described than by Edmund Gosse in his *Father and Son*. Therein the father, P. H. Gosse, an outstanding marine biologist in his day and a colleague in biology but not in theology of Darwin and Huxley, is pictured as, before all else, an adherent of a fundamentalist Protestant sect. Always with his mind on higher things, he made life intolerable for his young son by inquiring each day whether the boy had remembered to question his schoolmates on the state of

their souls. This is inhuman, but the sectarian cares nothing for the human being as such. Whatever the movement he joins may be, he sees little in life beyond certain categorical phenomena. The man whose mission it is to attack modern science is simply not interested in the fate of diabetics or cancer sufferers; they are not the object of his concern.

The biologist, however, has set up as his chief end the study of physiological processes and the curing of disease, and animal experimentation is an incident of it. He very often makes the mistake of thinking the opposition shares his values and can be reached by persuasion, so he states his case in terms of lives saved. A prized item in his armamentarium is the argument that work on animals is saving animals, too. (Indeed, it is said that Hearst has never been able to secure antivivisection legislation in his own state because the cattlemen of California know that such work has brought about the cure of anthrax and other bovine diseases, and they always oppose it.) But this, again, is saying the reasonable thing.

The mind of the sectarian, or fanatical, antivivisectionist is, like that of the religious mystic or, more obviously, of the political extremist, not accessible to reason. He is, in respect to mentality, one with the Negro-hater, the Jew-baiter, and all defenders of doctrines of racial superiority, in whatever guise. But in this case science, or the medical profession, is the scapegoat. Now, it is very doubtful if reason is the best weapon, or even a weapon at all, against such minds. The point was made recently, *mutatis mutandis*, by Professor Leslie White, of the University of Michigan, who, in reviewing Franz Boas' *Race and Democratic Society* commented as follows:

> Boas fought race prejudice for almost a half-century.... Yet it cannot be said that Boas ever gave an adequate scientific explanation of racial antagonisms and I know of no evidence that will show that all of his efforts diminished race prejudice by one iota.... He proves again and again that differences in behavior between such groups as Jews, Negroes, Nordics, Chinese, etc. are not explainable in biological terms. But most, if not all, of this preaching is futile—futile because it is irrelevant. Race prejudice is not engendered by an ignorance of anthropometry or neurology and it is not curable, therefore, by a learned dissertation on these subjects.... Boas' attack upon race prejudice is like an attempt to rid a psychopath of the delusion he is Napoleon by demonstrating his belief is scientifically ... unsound. But the psychopath's delusion arises from other causes and sources; it merely expresses itself in this particular form (*Amer. J. Soc.* 1947, **52**, (4) 371).

Public-relations men have an axiom: you can win the argument and lose the battle. Not specific argument, but the building of good relations between research men and the public, is the means to make sure that science will not suggest itself as a scapegoat to the moral revolutionary. This is a hard task and one that has never seriously been considered. Under the attacks of the antivivisectionists, some research men have suddenly discovered the fact that learning itself has foes, just as organized medicine found out what some of the public thinks of it only when the Wagner-Murray-Dingell bills brought the matter into the focus of public attention. As a means of meeting the onslaughts of the most active and clamorous of the antivivisectionists, the cultivation of favorable attitudes in the layman is slow, but it is also, one hopes, sure and, many times, rewarding. The present leaders themselves will probably never be won over, but the propagation of their faith will be made more difficult.

VIVIPARITY IN TELEOST FISHES

By C. L. TURNER

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THE habit of retaining the young within or upon the body of the parent is one that has arisen independently and repeatedly among animals. External appendages, gill cavities, mouth cavities, specialized pouches, and parts of the genital tracts have been utilized as sites for embryo retention. The female parent is most often the one with which the young have become associated, but the male parent has not escaped entirely. In some cases he goes about with a bulging brood pouch upon his body, or his mouth is so filled with his own progeny that he is unable to feed during his period of oral gestation. It is not surprising that a group of animals as biologically plastic and currently successful as the teleost fishes should have developed viviparity as one of its many diversions.

The fact that viviparity exists among the teleost fishes has been known for a long time. Nearly two centuries ago communications from corresponding members of scientific societies of London and Paris who were visiting America reported new instances of viviparity in American fishes.

Since that time many isolated cases have been described, and a little more than fifty years ago the first monographic studies began to appear. Within the past twenty-five years more intensive studies have been made upon restricted phases of viviparity. It is probable that all the major groups of teleost fishes in which viviparity occurs are now known. A review of the literature indicates that at least eight of the large groups have developed viviparity independently and that, within single groups the members of which are chiefly oviparous, viviparity has arisen independently a number of times. A comparative study of viviparity in mammals and in fishes reveals that there has been a certain degree of parallelism in the evolution of the adaptations, but that there also is a surprising amount of diversity in the adaptations of fishes, including superfetation and, in some extreme cases, retention of young until they are sexually mature. Neither of these adaptations ever appears in mammals.

There seems to be no relation between the development of viviparity and ecological conditions. The livebearing habit is found in both marine and fresh-water fishes. It occurs in fishes living in the cold, lightless depths of the sea, in dark fresh-water caves, in shore habitats, in the tepid waters of tropical lagoons, in swift-running streams, and in the lakes of elevated, sun-drenched plateaus. Some live bearers are bottom-feeding minnows, others are top swimmers and surface feeders, and still others are swift, efficient carnivores.

A search for a relation between viviparity in fishes and geographic distribution reveals only that viviparity may occur in widely distributed families such as the surf perches, the rock cods, and the brotulid fishes or in small isolated groups that have very limited geographic ranges. The comephorid fishes found only in Lake Baikal in Siberia and the goodeid fishes occurring only in the waters of the Mexican plateau and immediate vicinity are examples of groups confined to restricted ranges.

The terms "oviparity," "ovoviviparity,"

and "viviparity" are used in most of the literature to designate, respectively, those conditions in which eggs are not retained in the body after maturity and fertilization; those conditions in which eggs are retained within the oviduct or uterus after internal fertilization, but are equipped with an adequate yolk supply, and no nutritive materials are supplied by the parent to the embryo; and that condition in which the retained embryos become attached to the uterus by means of a placenta and derive their nutritive materials from the mother. The terminology bears the implication that each condition is static and that all cases must fall within one or another of these categories. As a matter of fact, there can be no sharp distinction among the different types because so many instances of live bearing in teleost fishes are in the process of evolving from one type into another. Furthermore, very little research has been done on the kind and extent of interchange between embryo and parent, and so the extent of physiological dependence of the embryo upon the female parent is not well known. There is no true uterus in the teleost fishes, only a physiological equivalent, and there is no actual attachment of retained embryos to the tissues of the parent. In view of these facts, and since the evolution of advanced types and of intermediate stages of viviparity will be stressed in this article, the accepted terminology is not suitable for use. The term "oviparity" will refer to conditions in which eggs are evacuated from the body before fertilization, and the term "viviparity" will be used for all cases in which eggs are fertilized before leaving the body and are retained even for a short time. The term "ovoviviparity" will not be used.

STRUCTURAL BASIS FOR VIVIPARITY IN TELEOST FISHES

In reading an account of viviparity in teleost fishes, it is natural that one will have in mind the better-known mechanisms of mammals or of elasmobranch fishes (sharks, rays). In all vertebrates above the cyclostomes, except the teleost fishes, whether oviparous or viviparous, the process of reproduction begins with ovulation, a process in which the ovarian follicle containing a mature egg becomes ruptured and the egg is evacuated into the body cavity. The egg is drawn into the oviduct, which it traverses, and if fertilization is external it is extruded from the oviduct and the cloaca in an unfertilized condition. If internal fertilization occurs, the egg is fertilized in the oviduct. The egg may then be evacuated through the cloaca or may remain within a modified portion of the oviduct to undergo a short or a long period of uterine gestation. Placental associations are developed between the embryo and the uterus if viviparity is well developed. The uterine wall may remain intact or be deeply eroded in the formation of the placenta. On the part of the embryo, the structures concerned in the development of the placenta are a chorion, the yolk sac with its vitelline circulation, and the allantois, a saclike structure which evaginates from the posterior part of the intestine. One or more of the structures are concerned in all devices by which an interchange of materials occurs between embryo and mother.

The teleost fishes differ from all the abovementioned vertebrates in a number of important structural characters that affect the condition of viviparity. In the first place, the viviparous teleosts do not have an oviduct. A short gonaduct extends posteriorly as a direct continuation of the muscular wall of the ovary, to open externally in the vent. When internal fertilization occurs, it must take place in either the gonaduct or the ovary itself, and embryos are harbored within the ovary or the gonaduct. The teleost fishes have never developed an allantois, and no allantoic (umbilical) circulatory system, which is so important in placental relations in the higher vertebrates, is ever

developed in the embryos. The vitelline circulation, including a network of capillaries upon the splanchnic covering of the yolk sac in the embryos of sharks and of higher vertebrates, is replaced largely by another network. The heart of a teleostean embryo lies upon the yolk sac, anterior and ventral to the body. All the blood that has circulated through the body must pass out of the body and through an elaborate portal network that covers the yolk sac and the wall of the pericardial cavity before it enters the heart. It should be emphasized that this is not the vitelline circulation of the other vertebrates, which, in some cases of viviparity, is important in the development of a yolk sac placenta. A structure that is a rough parallel of the chorion of the embryos of higher vertebrates occurs in the embryos of some teleost fishes. The pericardial cavity becomes expanded, and the somatopleural layer partially or wholly envelops the anterior part of the body by means of double folds. The external layer, the structural equivalent of the chorion in some other vertebrates, becomes vascularized by the portal network covering the yolk sac. The inner layer, a homologue of the amnion in some other vertebrates, is in contact with the body of the embryo. There is no amniotic cavity.

In brief, although the physiological requirements of the embryo in any well-advanced case of viviparity in a vertebrate must be similar, the embryonic structures and structural relations of the embryo to the mother in viviparity in teleost fishes are basically different from those that are concerned in viviparity in elasmobranch fishes and the higher vertebrates.

EVOLUTION OF VIVIPARITY IN TELEOST FISHES

The first step toward viviparity is intromission of sperm into the gonaduct. The males and females of many oviparous fishes bring the vents into close contact at the time of spawning, and the introduction of sperm through the vent into the gonaduct could be accomplished easily. It is necessary that the sperm be able to live, for short periods, at least, in the fluids of the ovarian cavity if internal fertilization is to be accomplished. In an incipient type of viviparity, ovulation would have taken place prior to fertilization, which occurs in the gonaduct or ovarian cavity, and after fertilization the fertilized egg, surrounded by its intact chorion, is extruded from the gonaduct quickly, so that little embryonic development occurs within the body of the female. Examples of this incipient type of viviparity are to be found in *Trachy choristes*, a Brazilian catfish, and in the phallostethid fishes of the East Indies. A climax case of viviparity, involving fertilization of the egg after it has been evacuated from the follicle into the ovarian cavity, appears to have occurred in *Zoarces*, a brotulid fish. Here the embryo is retained for a long period of time in the ovarian cavity, and evidence points to the occurrence of ovulation prior to fertilization. The ability of the sperm to remain alive within the ovary is partly a function of the ovary itself. In most cases in which viviparity has become well established, the epithelium of the ovarian cavity assumes a nurse-cell function, and the immobilized sperm becomes imbedded in the epithelium, to be kept alive for various lengths of time. In *Cymatogaster* the sperm are kept alive for months, and in *Heterandria formosa* live sperm are found in the ovary ten months after the female has had a single contact with the male. Long life of the sperm in the genital tract of the female has its parallels in reptiles and in mammals, but in these groups it is the oviduct rather than the ovary that provides the site for sperm retention.

The next basic step in the development of viviparity is the fertilization of the egg within the ovarian follicle before ovulation

has taken place (Fig. 1). Presumably this has been brought about by the earlier retention of sperm by the ovary and the harboring of the sperm in the ovarian epithelium. The ovarian epithelium is in contact with the wall of the follicle just before ovulation, and it would be necessary only for the imbedded sperm to penetrate the cells of the weakened follicle in order to reach the egg. Fertilization within the follicle prevents true ovulation. Since ovulation is controlled by a pituitary hormone, it would appear that some endocrine change has been brought about by, or is concurrent with, the new development of intrafollicular fertilization. Eventually, something equivalent to ovulation, namely, rupture of the altered ovarian capsule enclosing the embryo, must occur to release the embryo into the ovarian cavity, where it may be retained or extruded from the body immediately. The retention of the young embryo within the follicle sets the stage for further steps in evolution. Immediately after fertilization, the follicle cells that were concerned

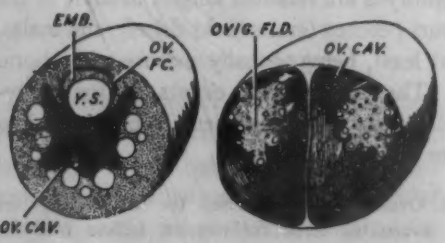

Fig. 1. Sections of ovaries to illustrate the positions within the ovary of embryo retention. In follicular gestation (*left*) the embryo (EMB.) with its large yolk sac (Y. S.) is retained after fertilization within the ovarian follicle (OV. FC.) and is evacuated at birth through the ovarian cavity (OV. CAV.). Gestation in the ovarian cavity (*right*, OV. CAV.) occurs in some forms after the egg has been fertilized in a follicle of the ovigerous tissue (OVIG. FLD.) and evacuated from the follicle into the ovarian cavity.

in the building up of the immature egg disappear or are radically changed, and the follicle is transformed into a vascular capsule that envelops the young embryo. The yolk sac, often a large one more than 3 mm. in diameter, is capable of providing food materials for a long stay in the follicle, but respiration and the elimination of wastes

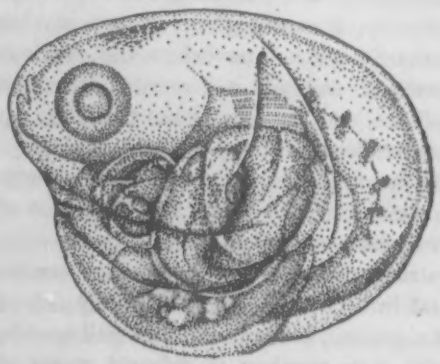

Fig. 2. A complete ovary of a poeciliid fish containing six small broods of embryos in different stages of development at the same time, to illustrate superfetation. The smallest spheres at the base of the ovary are embryos in the first stage of development.

must be provided for by an exchange through the permeable membranes of the follicular capsule and the yolk sac circulation (portal system) of the embryo. Once this physiological relation has been set up, the permeability of the membranes could be (and has been) altered so that nutritive materials may be conveyed to the embryo. This situation would be favorable for the concurrent reduction of yolk material in the egg and for new developments in the embryo and in the follicle wall that would increase the efficiency of the exchange of materials. This condition might be called "follicular gestation." This trend of evolution has occurred independently twice within the order Cyprinodontes. A parallel evolution toward reduction of yolk sac, with a concurrent development of new structures that provide efficient exchange between embryo and parent, has occurred in the mammals.

Another new direction evolution may take in fishes having follicular gestation is that of superfetation (Fig. 2), the condition in which two or more broods of embryos at

different stages of development are harbored within the follicles of the ovary at the same time. The condition has been evolved by the shortening of the period required for developing and maturing the egg. Apparently, a second group of eggs reaches maturity some time before the previous brood of embryos is evacuated from the follicles, and the eggs of the second group are fertilized, each egg within its follicle. In the same manner, other groups of eggs may come to maturity before the first brood of embryos is evacuated (Fig. 2). In the most extreme cases, seen in *Heterandria formosa* and in several species of *Poeciliopsis* and *Aulophallus*, as many as nine small broods, with their members in different stages of development, are found in the ovary at the same time. Effective superfetation, as far as is known, occurs only in the poeciliid fishes of the order Cyprinodontes, and in this family it has arisen twice independently. Effective superfetation does not occur in those vertebrates that have uterine gestation.

A second site in the ovary within which embryos may be retained is the ovarian cavity (Fig. 1). The type of viviparity involved in the retention of embryos in this position has arisen, except possibly in some brotulid fishes, from the older type of follicular gestation. The most advanced types occur in species in which the yolk sac has become greatly reduced. Conditions here are remarkably different from those in follicular gestation. The embryos are not separated from one another as they are in follicular gestation. They are all contained in a space lined by the epithelium of the ovarian cavity and bathed by a fluid secreted by the epithelium. Many of the embryos die and the bodies disintegrate. They are either absorbed by the ovary, or the remaining parts are ingested by the surviving embryos in a kind of intraovarian cannibalism. Gestation in the ovarian cavity is preceded by fertilization of the egg within the follicle. The egg is retained in the follicle for some time in *Sebastodes*, in the jenynsiid fishes, and in some of the brotulid fishes and is then evacuated into the ovarian cavity with the chorion still intact. In *Sebastodes* the retention in the ovarian cavity is short. The brood, consisting of thousands of embryos, is born to hatch and to develop thereafter in the manner characteristic of oviparous fishes. The period of retention in the follicle is very brief in the goodeid fishes, the embiotocid fishes, and some of the brotulids. The follicular wall breaks down and the chorion is ruptured while the embryos are in the segmentation stages, and the naked embryos are moved into the ovarian cavity. In those species in which the embryos are retained for a long period in the ovarian cavity after their evacuation from the follicle, there are some remarkable adaptations for facilitating the exchange of materials between embryo and maternal blood. The small yolk sac, sometimes quite minute, is quickly absorbed, and the food supply for later development must come from the mother. The embryos are retained longest in some of the surf perches (embiotocid fishes), the males, at least, being sexually mature when born.

The sequence of events in the reproduction and development of typical oviparous fishes is as follows:

1. Ovulation, during which the mature eggs are evacuated from the ovarian follices into the ovarian cavity.
2. Extrusion of the eggs, which are surrounded by an intact membrane, the chorion, to the outside of the body through the gonaduct and the vent.
3. Fertilization, which is external.
4. Hatching, which involves rupture and discarding of the chorion.
5. Larval development, during which the immature embryo leads an active life and is responsible for securing its own food and providing for its own protection.
6. Maturing, during which reproduction occurs.

In viviparous fishes the sequence of events is changed, and some or all of the events occur within the body of the female parent.

There are many modifications of the sequence, which is characteristic of oviparous fishes. Ovulation may be postponed until an encapsulated embryo has developed to the equivalent of a late larval stage in some poeciliid fishes, in hemirhamphids, and in *Anableps*. Fertilization has preceded ovulation, and, when ovulation does occur, it is followed immediately by hatching and birth. In different cases hatching may occur outside the body, within the ovarian cavity, or in the ovarian follicle. The stage of development at hatching may be that of early segmentation, early larva, or postlarva. The embryo finally evacuated from the body may be an egg which has just been fertilized, an early larva, or even a sexually mature fish. The endocrine controls of the processes of ovulation, elaboration of eggs, gestation in ovarian follicles, or in ovarian cavities, and birth of the embryos have been studied scarcely at all. It is obvious that a wide variation exists in these controls in the different types of viviparity in teleost fishes.

ADAPTATIONS FOR VIVIPARITY IN EMBRYOS AND OVARIES

In cases of incipient viviparity there are practically no structural features in either embryos or ovary that are notably different from those in oviparous fishes. In follicular gestation and in gestation within the ovarian cavity, there are some simple modifications of structure in cases in which the embryos have an adequate yolk supply for their periods of gestation. A striking series of new structures, which are temporary, exist only during gestation, and are associated with the exchange of materials between embryo and ovary, appears in cases of viviparity in which embryos have a small yolk supply. This is true of embryos harbored within ovarian follicles or ovarian cavities.

Follicular gestation. In simple follicular gestation the embryos are provided with a supply of yolk adequate for their period of gestation. The portal circulation upon the yolk sac and the pericardial sac is much like that found in oviparous fishes, but the pericardial sac is usually expanded as a sac or a hood, which is drawn over the head (Fig. 3). The follicular sac which encloses the embryo becomes fibrous and vascular while it surrounds the embryo, but there are no other changes in the ovarian tissue.

Follicular gestation involving embryos with small yolk masses is accompanied by the development of a number of extreme and temporary modifications in both embryos and ovaries. In *Heterandria formosa*, a poeciliid fish, a hood formed by the pericardial sac is greatly expanded, and the peritoneal

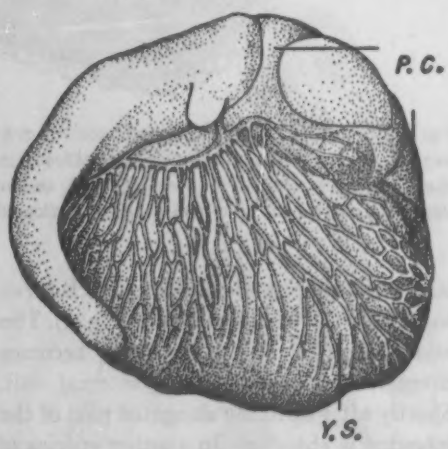

Fig. 3. Embryo of poeciliid fish with fairly large yolk sac. A part of the pericardial sac is drawn over the head in the form of a hood. The yolk sac (Y. S.) and a part of the sac containing the pericardial cavity (P. C.) are covered by a portal network.

sac also is enlarged. At an early stage the urinary bladder becomes expanded and pushes into the pericardial and peritoneal cavities. The diminutive yolk sac is absorbed at an early stage. The follicular wall becomes very thin, highly vascular, and closely applied to all the exposed external surfaces of the embryo. In *Anableps anableps* there is a great expansion of the pericardial and peritoneal sacs, and the portal circulation, which covers both sacs, develops

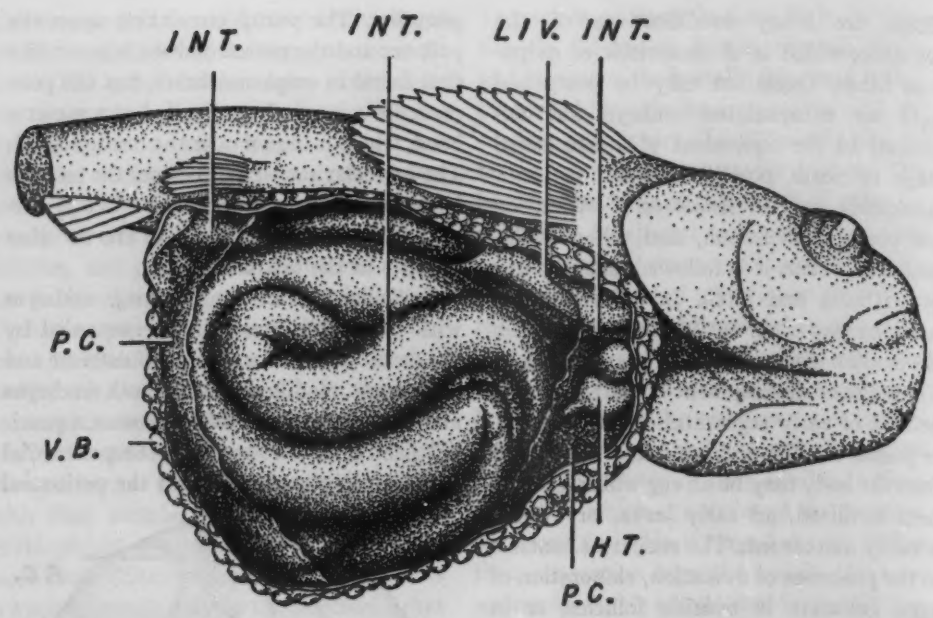

Fig. 4. Embryo of *Anableps* removed from the ovarian follicle. The enlarged belly sac has been dissected away to expose the internal organs. Special features are: enlarged pericardial sac (P. C.), covered by bead-shaped enlargements of blood vessels (V. B.); and intestine (INT.), the middle portion of which is enlarged, elongated, and coiled. Liver and heart are indicated by LIV. and HT.

large bead-shaped protrusions, which serve to increase the vascular surface (Fig. 4). The middle portion of the intestine becomes elongated and develops long internal villi. Shortly after birth the elongated part of the intestine is absorbed. In another species of *Anableps*, it is the posterior portion of the intestine that undergoes temporary enlargement. The internal surface of the follicle surrounding the embryo puts out great numbers of fine, finger-shaped vascular processes (follicular villi). A loose placental relationship is thus established between the vascular wall of the follicle and the vascular surfaces of the pericardial and peritoneal sacs of the embryo (Fig. 5). Similar modifications producing an increase of the inner surface of the follicle are found in several species of poeciliid fishes.

Gestation within the ovarian cavity. All the instances, with one possible exception, in which the embryos are retained in the ovarian cavity have arisen from types which earlier in their evolution retained the

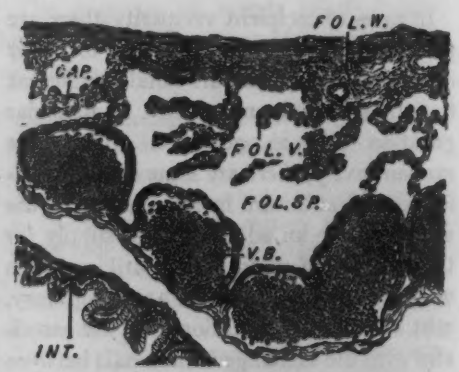

Fig. 5. Section to illustrate the relations between an embryo of *Anableps* and the wall of the follicle in which it is enclosed. The follicle wall (FOL. W.) is equipped with internal villi (FOL. V.), which contain capillaries (CAP.). A narrow space (FOL. SP.) separates the follicle wall from the external wall of the embryo with its rich vascular bulbs (V. B.). The enlarged intestine (INT.) lies in the body cavity.

embryos for some time within the ovarian follicles. The expanded and vascular peritoneal and pericardial sacs characteristic of the follicular type of gestation are present in the embryos for a short time and are reminiscent of the earlier type of gestation. These structures have a fleeting existence, however, and are quickly replaced by other new structures upon which the embryo depends later while enclosed within the ovarian cavity. Embryos of the jenynsiid fishes of South America develop enlargements of the peritoneal and pericardial sacs while contained in the ovarian follicles, but after evacuation of the embryos into the ovarian cavity there is a recession of the sacs. Later, flattened, leaf-shaped processes grow out from the walls of the ovary and become inserted under the opercula of the embryos. Further growth of the tissues of these ovarian flaps partially fills the gill and mouth cavities (Fig. 6). Shortly before birth the embryos are freed from the flaps. In the goodeid fishes of the Mexican plateau the early history of the embryos is much like that of the jenynsiid fishes, but after evacuation of the embryos into the ovarian cavity long, finger-shaped or flattened extensions grow out from the anal lips of the embryos (Fig. 7). The extensions are known as *trophotaeniae*. In *Parabrotula*, a deep-sea brotulid fish, flat, ribbon-shaped structures grow out from the region of the anus and the urogenital pore while the embryo is retained in the ovarian cavity (Fig. 8). One of the most remarkable of the temporary structures that are developed is a series of flattened vascular extensions of the soft tissues between the ends of the rays in the vertical fins in the embryos of the embioticid fishes (Fig. 9). In addition, the embiotocid embryo has a great expansion of the posterior portion of the intestine. *Zoarces*, a brotulid fish, has a parallel development of an enlarged intestine in the embryo during ovarian-cavity gestation.

Structural changes of a cyclical character occur in the tissues of the ovary during gestation. When the embryos are first evacuated into the ovarian cavity, the cells of the epithelium surrounding the cavity become high and columnar and their secretory activity is increased. At the same time the connective tissue of the ovary becomes swollen. Large numbers of free cells appear in the semifluid connective tissue. Somewhat later there is a general increase in the vascularity of the ovary, and a rich capillary network develops just beneath the epithelial lining of the ovarian cavity. Following the increase in vascularity, there is a general shrinking of the connective tissue. After the

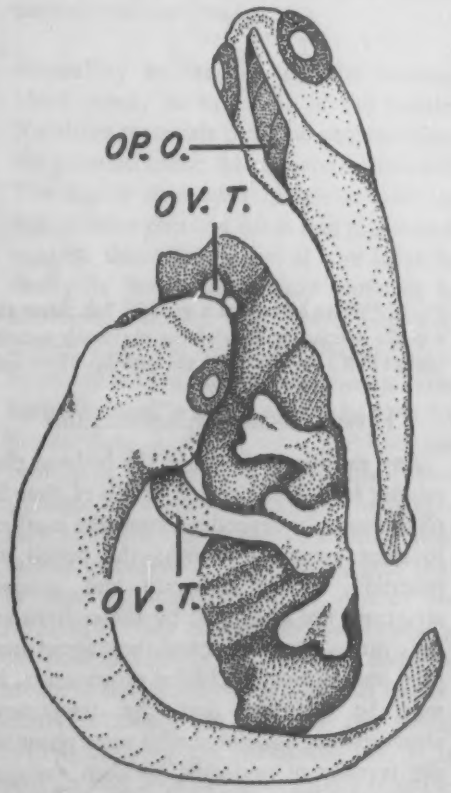

Fig. 6. Embryos of a jenynsiid fish removed from the ovarian cavity with a part of the ovarian wall. Leaf-shaped extensions of the ovarian wall (OV. T.) grow into the opercular openings (OP. O.) of the embryos and partially fill the gill cavities and mouths of the embryos.

embryos are born, the ovarian tissues undergo involution, and the conditions existing in the ovary prior to fertilization of the eggs are restored. Some of the blood vessels remain permanently enlarged.

variety of adaptive structures associated with viviparity in teleost fishes the techniques that have been employed in the study of the physiology of the mammalian placenta.

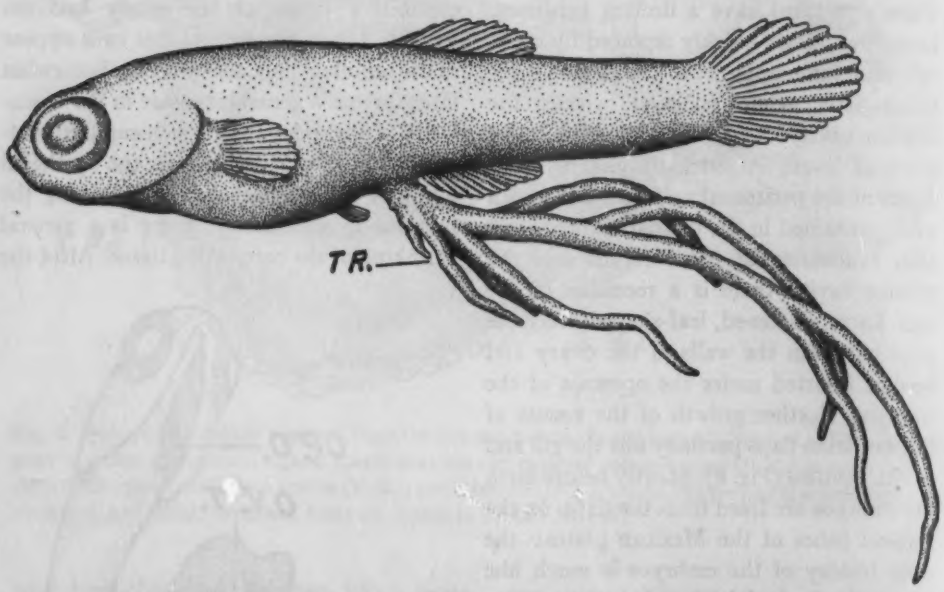

Fig. 7. Unborn embryo of a goodeid fish. After the embryos have evacuated from the ovarian follicles into the ovarian cavity and the previously enlarged pericardial sac has receded, the vascular trophotaeniae (TR.) grow out from the anal lip. These temporary absorptive organs are lost at birth.

PHYSIOLOGICAL INTERPRETATIONS

Any embryo harbored in the body of the mother for a considerable length of time is physiologically dependent upon the mother to some extent. If, during the period of retention, highly elaborate and unique structures are developed by the embryo or the ovary of the mother and these structures exist only during the period of gestation, it may be assumed that the temporary structures are associated with some phase of the transfer of materials between embryo and mother. There is little exact information on the transfer of materials, and most of the physiological interpretations are inferential. A field of research is open to any investigator who will apply to the bewildering

The most important physiological requirements of the embryo are those associated with the obtaining of nutritive materials, water, salts, and oxygen and the voiding of waste materials. It is generally conceded that nutritive materials are furnished by the yolk and that respiratory interchanges are carried out in vascular external coverings of the yolk sac and the expanded pericardial sac in embryos equipped with large yolk sacs. Nitrogenous wastes must either be voided by way of the parental blood stream or stored in a sac with a membrane impermeable to the wastes. In *Heterandria formosa* there is a great temporary enlargement of the urinary bladder during gestation, and it is possible

that urinary wastes are stored in it as they are in the allantoic sacs of some of the higher vertebrates. The absence of such specialized structures in other species would indicate that urinary wastes are voided into the follicles (in follicular gestation) or into the ovarian cavities and are then removed by absorption into the maternal blood stream.

In cases of specialized follicular gestation in which the embryos have very small yolk supplies, the portal system on the expanded pericardial sac is in a position to provide for

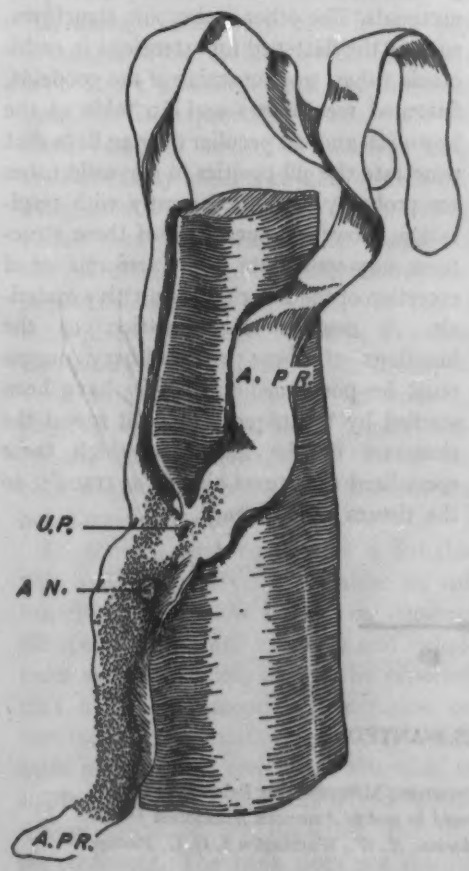

Fig. 8. Posterior part of an unborn embryo of *Parabrotula*, a deep-sea brotulid fish. The ribbon-shaped membranes, or anal processes (A. PR.), develop anterior and posterior to the anus (AN.) and the urogenital pore (U. P.). The membranes of the processes absorb materials from the fluids of the ovarian cavity in which the embryo lies.

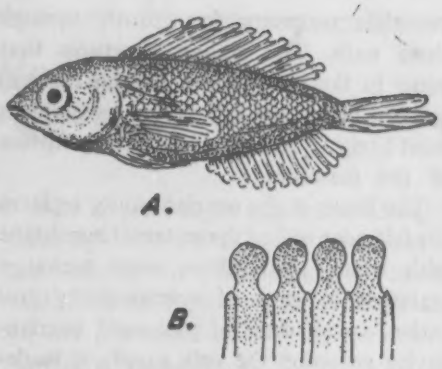

Fig. 9. *A*. Unborn specimen of an embiotocid fish. The male is sexually mature at this stage. *B*. Flat extensions of soft tissue between the ends of the rays of the vertical fins. These vascular protrusions are assumed to facilitate respiration.

respiratory exchanges with the maternal blood supply in the walls of the follicles. Nutritive materials must be obtained from the parental blood through the follicle wall. The highly developed glandular follicular villi in some poeciliid fishes and in *Anableps* suggest that the liquor of the follicular cavity is being continually enriched by secretions from the villi. The embryo may absorb materials from the follicular liquor by one or both of the following means. It has been observed in living specimens that follicular fluid is drawn into the branchial cavities of the embryos and is then passed through the alimentary canal. The temporary modifications of the alimentary canal during gestation in *Anableps* suggest that in this and probably other species absorption by way of the alimentary canal is the principal device by which the embryos secure nutritive materials. A second mechanism for absorption may be the portal system covering the pericardial sac. It is obvious that a considerable supply of nutritive materials must be secured by an embryo which has a yolk mass less than 1 mm. in diameter at the time of fertilization but has a length of 55 mm. at birth. It is obvious also that, being completely enclosed by the follicle walls, the embryo must obtain the

materials necessary for growth through these walls. The unique structures that occur in the embryo only during the gestational period are interpreted as the ones most likely to be concerned with absorption of the materials.

The lining of the ovarian cavity replaces the follicular wall as the maternal membrane with which the embryo must exchange materials in cases of ovarian-cavity gestation. In all cases of prolonged ovarian-cavity gestation the yolk supply is inadequate for the nutritional requirements of the embryo, and the pericardial sac, after a short existence as an expanded organ, is absorbed. It may be assumed that as long as the yolk supply lasts it is used for nutritional requirements, and up to the time of its resorption the surface of the pericardial sac is used in respiration and possibly excretion. Nutritive requirements are met, at least in part, after the absorption of the yolk and the pericardial sac, by materials ingested from the ovarian cavity. The material consists of masses of cells desquamated from the epithelial surface of the ovary, from secretion of the epithelium, from substances in solution that are derived by absorption from the maternal blood, and from dead and disintegrating embryos. Parts of the intestine of the embryos become enlarged, and their absorbing surfaces are increased by the formation of folds and villi. This feature is found in nearly all cases of ovarian-cavity gestation, and, since the groups in which it occurs are only distantly related, it must have arisen separately in the various groups. The general occurrence of an enlarged intestine and the finding of quantities of partially digested materials in the intestine lead to the conclusion that ingestion of materials from the ovarian cavity is the principal mechanism for obtaining nutritive materials. The other embryonic structures, such as the flattened fin extensions in embiotocid fishes, trophotaeniae of the goodeids, flattened membranes and fin folds of the brotulids, and the peculiar ovarian flaps that penetrate the gill cavities in jenynsiid fishes are probably concerned mostly with respiration. However, one or all of these structures may contribute to the performance of excretion or the securing of nutritive materials. A positive interpretation of the functions of these extraordinary organs must be postponed until they have been studied by techniques that will reveal the character of the materials which these specialized structures absorb or transfer to the tissues of the ovary.

BACK ISSUES WANTED

Receipt of copies of 1947 issues of THE SCIENTIFIC MONTHLY *for February—August, inclusive, will be greatly appreciated. They should be sent to American Association for the Advancement of Science, 1515 Massachusetts Avenue, N. W., Washington 5, D. C. Postage will be refunded.*—Ed.

Book Reviews

MAN MARKS THE EARTH WITH RUIN

Elements of Soil Conservation. Hugh Hammond Bennett. x + 406 pp. Illus. $3.20. McGraw-Hill. New York. 1947.

THE phrase "soil conservation," although extensively used in the past decade, is not of uniform definition or concept. In Dr. Bennett's book, too, confusion over this point prevails. In one place soil conservation is defined as meaning "using land efficiently under a farming system that safeguards it from erosion;" elsewhere it is stated that "soil conservation consists of safeguarding all kinds of useful land against impoverishment or depletion;" in still a third place, "soil conservation is, therefore, the scientific use of land." Such broad, diverse definitions as these detract from the main objective of the book, namely, soil-erosion control. Perhaps the title of the book might better have been "Elements of Soil-Erosion Control."

Of course, what constitutes a suitable title and range of subject matter on soil conservation depends largely on personal viewpoint, and, until concepts and definitions are crystallized, it is to be expected that a certain amount of confusion on terminology will exist. Certainly it would seem necessary to give more attention to soil fertility if soil conservation is to include the problems of soil depletion and impoverishment. The book does not discuss soil fertility, either in principle or in practice, and it is possible that some readers might erroneously conclude that control of erosion is all that is required to obtain high crop production.

Dr. Bennett urges that more science be used by the farmer in laying the foundation for the better use of his own and the nation's soil resources. He contends that many acres of our soil resources have been ruined or seriously injured by accelerated wind and water erosion. Through the application of scientific knowledge now at hand, or by gathering additional factual information, it is possible, he argues, to prevent or control excessive deterioration of our soil. To do this, he believes that it is necessary for the general public, as well as the farmer, to give greater attention to basic land facts. Some of these, as outlined in the book, are that our supply of really good land is limited, and that much of this really good land, as well as land of lesser quality, is subject to the wasteful process of soil erosion. With all these general arguments, serious students of our soil resources will readily agree.

On more specific points, there will not be such universal agreement. In one of the chapters on the erosion problem, it is pointed out that the early rapid settlement of our nation took a huge toll of soil resources, and it is implied that the pioneer settler had a "false philosophy of plenty." If the pioneer did make errors in clearing land for cultivation, it was because he was working with soil and climatic conditions alien to his experience, and it was on a trial-and-error basis that he proceeded. Even today neither our knowledge of soil-erosion control, nor our ability to apply it, is such that there will be no errors—perhaps serious and costly ones, at that—in the whole problem of proper land use.

What are some of the lessons that we have so painfully learned? That not all our soils

are suited to cultivated crops; that some soils are too stony, or too sandy, or too deficient in plant nutrients, or too droughty, or too sloping to grow grain crops in sufficient abundance for an adequate standard of living. We have also learned, as Dr. Bennett points out in How Erosion Takes Place, that wind and water are active causes of soil erosion. We have learned that both productive and unproductive sloping soils are subject to these relentless agencies. As also pointed out by the author, we have further learned that the rate at which the surface soil is lost depends on many variables: slope gradient, the nature of the vegetative cover, the properties of the surface and lower layers of the soil itself, and the intensity of wind and water factors. We have learned by controlled experiment, and by hard experience, that different kinds of soils require different practices to control erosion.

It seems to me that the author is somewhat too critical of agricultural scientists for failing to sense the "full effects of erosion." He implies, too, that soil depletion, land abandonment, and the migration of farmers are always related to erosion. This is painting far too simple a picture. It is a fact, also, that the soil-erosion problem was recognized by many agricultural scientists more than two decades ago. Lack of funds for research and education or the imperfect development of facts about soil properties can be said to be the main reasons for not accomplishing more in the solution of the erosion problem. If the early workers had expended all their available funds for research on soil erosion, it would have meant that little knowledge on the fundamentals of soil fertility would have been accumulated. Certainly knowledge of the role and use of rotations, lime, and fertilizers is of the highest importance to the low-cost, high-quantity production of food and fiber crops—and for the control of soil erosion, too.

Soil-erosion control involves, as Dr. Bennett says, a knowledge of plants, soils, climatology, and engineering; and, as far as is possible in a book of this brevity, discussion of some applied phases of these topics as they relate to certain soil- and water-management problems is included. Cooperation between different sciences, both basic and applied, is not, of course, a new concept or practice. In agriculture, as in industry, a team of scientists is often needed to solve many problems. But we should not forget that it is the highly specialized scientists who give us hybrid corn and improved strains of cotton, or who unravel the complex problems of soil fertility.

It is difficult, and perhaps too early, to determine to what audience this book will have the most appeal. Information in certain portions of the book, which is also available in numerous bulletins and journals, has already formed the nucleus of high-school and elementary college courses in soil-erosion control. Public officials and businessmen, as well as farmers, will find the book useful and will be able to obtain from it a better understanding of the nature, significance, and control of soil erosion. The many references to Federal and state agencies concerned with educational and research projects in soil conservation might perhaps have been more suitable in another book, say, one on the function and relationship of governmental agencies to a soil-conservation program.

Dr. Bennett is nationally known for his association with the Soil Conservation Service, but his long career in the United States Department of Agriculture is not so well known. Nearly forty years ago, he started as a soil surveyor, later becoming Inspector of Soil Surveys. His duties carried him to many parts of the United States, Alaska, and Cuba. His early and continuing interest in the problem of soil erosion led, in the late twenties, to the responsibility of organizing and supervising

a number of experimental farms for the purpose of studying how soil erosion occurs and methods for its control. Dr. Bennett, therefore, was a pioneer in the important task of preparing a scientific classification of the soils of the United States. His versatility in soil science enabled him to develop and administer the Soil Conservation Service of the Department of Agriculture, which is playing such an important part in a better agriculture.

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HISTORY OF SCIENCE

Benjamin Silliman: Pathfinder in American Science. John F. Fulton and Elizabeth Thomson. 304 pp. Illus. $4.00. Schuman. New York. 1947.

BENJAMIN SILLIMAN was a son of the American Revolution. Before him, in direct line, were John and Priscilla Alden. In his conscience still lingered a righteous Puritan heritage, though happily tempered by a sense of humor and a saving curiosity about life. At Yale College, where he graduated in 1796, he "experienced a spiritual rebirth that sustained him as long as he lived."

Silliman was tall and handsome, with manners gracious beyond his years. He would not be content "to walk obscurely along through some sequestered vale of life."

After graduation he studied law with the Honorable Simeon Baldwin. Six months after passing his examinations for the bar, Silliman became the first professor of chemistry and natural history at his alma mater. This is the strange beginning of the history of science at Yale, then resolutely orthodox, although it had been whispered that Ezra Stiles, once president of the College, had been "flirting with alchemy."

Fortunate it was that Silliman had been born "at the precise moment when his particular talents could be put to their most effective use." Whatever Silliman lacked as a scientist, he compensated for by his charm and his enthusiasm for science. With an unusual gift of expression, he captivated even those who saw in geology a foe to the Mosaic doctrine of creation. That he was able to reconcile the one with the other stood him in good stead, though Huxley once slyly remarked that Silliman wrote "with one eye on fact and the other on Genesis."

Silliman knew little or no chemistry. He obtained a few books, hid them in his desk, and occasionally read them privately. Soon he departed for Philadelphia to study. There he met Joseph Priestley, who "had become obnoxious to his native country on account of political and religious opinions." Silliman seems to have been a little impatient with Priestley, who forgot "that physical causes may be the moral agents of the Almighty." Returning to his "underground chamber" at Yale, he tarried but a brief time before setting out on a voyage to England, there to further the preparation for his teaching of science.

He found England in anxious preparation for invasion by Napoleon, who had massed formidable armies for crossing the Channel. Silliman saw Nelson depart to the glory and tragedy of Trafalgar. In London he found delight in the antiquities of the city, in the people he met, and in the theater, though he was somewhat shocked by the "indecent dancing" and the witticisms inscribed in the Poets' Corner of Westminster Abbey. He was troubled not a little, too, by "the instruments of gambling" he found in the hands of the Fellows at Caius in Cambridge. In Edinburgh he settled down to the more serious business of science.

Silliman was stirred by beauty as well as by truth. Not only did he find a cellar chamber for his laboratory and collection of minerals, but he also brought to Yale the paintings of the Revolution by the great

Trumbull and so encouraged an interest in the fine arts.

He labored long and arduously at his teaching and with his public lectures on science. These he carried to an ever-increasing audience of attentive and enthusiastic followers. It would seem, however that his son, Benjamin, Jr., took a slightly darker view of this part of his father's activities: "It seems like casting pearls before swine to take so much pains for those who for the most part appreciate it so little."

Silliman's *American Journal of Science* became the repository for the scientific thought of his time, and through it his influence reached across the Atlantic. He never lost an opportunity to increase the influence of science at Yale. His concept of science was utilitarian; he was "never an advocate of the study of 'pure' science confined within the walls of a laboratory—science for science's sake—he wanted to put knowledge in the hands of all who could do anything to promote its growth and usefulness."

From the pages of this book Silliman comes forth a figure with less depth and fullness than his achievements proved him to possess. His profile seems slightly out-of-focus. A child of his times, he thought as did his contemporaries, yet he saw beyond them. That he was not interested in science for its own sake, but rather in the practical employment of its work, need not have been cause for indulgent satisfaction. That was not the quality of Silliman that made him great. It was his defect. Had not his successors seen differently, the practical in science would long since have been exhausted, and science today would be sterile. What Silliman began, a few who caught his enthusiasm carried to new and more significant heights.

He conceived the first graduate school in America. Inadequate as it was, it nurtured some who were to create a new tradition. Silliman was but the link between the past and the present, however vital that link may have been. The new school he fostered allowed the student investigators "complete freedom to find their own way into the world of science." From this atmosphere there came two men of genius. One was J. Willard Gibbs, who was "probably the greatest scientist this country has yet produced." And there was also Daniel C. Gilman, who gave to America its first university.

Silliman's "ability consistently to win for science the support of the Yale Corporation, composed almost entirely of theologians, was phenomenal. Here he was notably aided by his strong religious faith and his personal warmth."

That Silliman was a deeply religious man there can be no doubt. Otherwise, in his time and in his place, he quite possibly would have failed. Yet Silliman was adaptable. It may be that too much emphasis is placed upon this quality, as if the same religious orthodoxy he so fully and honestly possessed might well be emulated by those who follow in his scientific footsteps. But this is beside the point of Silliman's life. May not his successors of today be as fully religious in their way as was Silliman in his? What humility must come to one who looks into the majestic and awful distances of the heavens, or into the microcosm of the atom with its equally awesome plan and order. Perhaps these men, too, as did Silliman, feel the mystery of the universe, even more fully than could their early predecessor when he beheld the revelations of the ancient prophets in a simpler age. But those who seek the truth today may find their religion no more static than their science.

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Comments and Criticisms

ERRATA

These comments concern two articles in the July 1947 SM. The first is S. H. Gould's "The Theory of Relativity and the Atomic Bomb," an interesting article, which, however, does not stay very closely with its title and which involves some misstatements of fact. On page 51 the author mentions " . . . Einstein's transformation, named after the Dutch physicist Lorentz. . . ." But the transformations mentioned are not originally Einstein's and were not simply named after Lorentz. They were first enunciated and employed by Lorentz, interpreted by Fitzgerald as a physical contraction in size, and were finally interpreted in a different way by Einstein.

Again, on page 54, the writer states that "Einstein . . . assigns the motion of the Russian rivers, not to any absolute rotation of the earth, but to rotation relative to all other matter in the universe, and in particular to the immense masses of the stars." All this without any mention that it was Ernst Mach who first conceived and worked out such a theory of rotation, which was later included by Einstein in his theory and which incidentally is one of the weakest points therein. Such omissions are too reminiscent of those scientifically illiterate discussions which know only the much-publicized name of Einstein when it comes to relativity theory.

Third, the author is quite far behind the times in naively accepting (p. 60) the literal interpretation of the notorious relativistic paradox of the two travelers. This has long been explained in very clear and understandable terms based simply on the fact of the finite speed of light used in reading or recording time on each of the traveler's clocks. For a third clock at home base would record the same time lapse for each, and the travelers would not return one an old man and the other still young, as the common fallacy and S. H. Gould would have us believe.

The second occasion for our comment, the article "Man, the Myth-Maker," by Read Bain, is more serious both in its nature and consequences. On page 68 this writer states as his conclusion and suggestion that "a deliberate attempt to disseminate the scientific habit of mind widely, especially as it pertains to social phenomena, might hasten the decay of secular myths." Thus far, fine; but he continues with details of his conception of achieving this: "Children could no longer be told lies and fairy tales—they would have to be oriented to the world as science sees it; religion would have to preach only such doctrines as are consistent with the methods [sic] and findings of science; artists of all kinds would have to eschew fantasy and espouse facts. . . ."

And we read all the above example of a modernized form of bigotry after the author's admission on page 67 that "all single-factor, oversimplified explanations of social phenomena and remedies for social problems are mythic. . . . A man is myth-minded when he becomes obsessed by some particularistic methodology or theoretical point of view to the exclusion of all others. He is ready to brand other scientists as 'not scientists' if they do not share his methodological manias. . . ." No better illustration of these points could be found than the same writer's own passage, beginning "Children," etc., quoted above. Indeed throughout the entire article the author constantly resorts to name-calling, using the word "myth" and its variants as terms of ridicule and opprobrium to decry any and all who would not care to subscribe to his own brand of uncritical materialistic naturalism, which in point of fact is today becoming superseded in the philosophy of science, and actually represents a vestige from the nineteenth century.

A.A.A.S. has a section of its organization and membership devoted to psychology. It would be instructive to submit the passage in question to the scrutiny of several competent psychologists, requesting their opinion of it as a program for releasing scientifically the best in men's natures. I am quite sure their verdict would be unanimous in regarding Bain's well-nigh rabid diatribe a quite unscientific conception and one revealing a surprisingly intolerant attitude toward the whole vast realm of the imaginative and creative life of man, not important alone to art (which would shortly be stifled under such scientific fascism), but also to great scientific discovery.

An even more serious blunder is made (p. 67) in lumping "Marxism, capitalism, and democracy" as "ill-defined, all-inclusive concept[s] based on hope and fear." He may be right about the first two, but certainly democracy as historically evolved through the pens and actions of America's first great statesmen, the democracy of a Federal system of otherwise sovereign states that today provides the pattern

for world government and peace—this is far from ill-defined, for it means the brotherhood of man itself. It is not based on fear, either, but rather on the legitimate hope that such brotherhood may be a fact global in extent— our only safeguard for scientific progress, and indeed for humanity and social relations as a whole.

I deeply feel that the overwhelming majority of scientists worthy of the name do not share the polemic and uncreditable aspects of the views to be found in Bain's article, which, if carried to their logical conclusion, would tend to pervert scientific activity into intellectual arbitrariness and dictatorship.

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THE ALUMINUM RULE

A couple of weeks ago I heard Professor R. A. Millikan take to the microphone—for true religion, of course. Since then, I have reread A. H. Compton's "Science and the Supernatural" (SM, December 1946). For two gentlemen who have had their differences, they do sound singularly alike. One wonders: does their explicit contradiction on the objective level of science perhaps reflect an implicit contradiction on the subjective level of religion, despite appearances? Such is indeed the case. But as Hegel said: it is not the contradiction of the idea by reality which constitutes the error; it is the contradiction of the idea by itself.

It is fairly clear that in Millikan and Compton, we have two Millikans, two Comptons; one private, one public; one religious, one scientific. Each unquestionably claims an equal right to each kind of belief. Nevertheless, the inner logic of their position compels them to arbitrarily bridge the gulf of their dualism. They do make public their private beliefs; they do afflict and invade my privacy, for instance, with them. "Truths" grounded upon subjective verifications thus become guilty of trespassing. Only objectively verifiable, scientific truths are entitled to the public places. If it is retorted: "Read, write, and speak and live your own beliefs," the point is precisely demonstrated; for then, logically, only violence can become the common ground for contradictory beliefs so founded.

Pietism, however diluted for the sake of plausibility, is anything but the virtue it presumes to be; it is simply latent conflict, self-conflict generating the smoke of self-deception. It does not comprehend the relativism of the private-public, the subject-object relationship. Whatever its ontological or epistemological forms, it directly stems from one "absolute" principle recognizable to every man: between the individual interest and the public interest there lies an impassable gulf.

T. V. Smith, in another article in the same issue of SM (having nothing to do with Millikan or Compton), reproved the invasions of privacy of the Compton-Millikan variety. Smith pointed out their self-contradictory character; but beyond that, he, too, had little to offer. When last observed, he seemed headed straight for solipsism—with only his own inconsistencies standing by to save him. His conception of the self, though less mechanical than the others, nevertheless assumes the character of an inviolate particle, the ultimate measure of itself, its fellows, and the surrounding field. Compton and Millikan believe unabashedly in having their cake and eating it, too; they seem comparatively expansive with the stumps of their dualism to limp about on. Smith is contractive, refusing to either have or eat his cake, but preferring to snitch small pieces of it when nobody is looking.

These errors, several in form but identical in content, all result from assuming the subject as the fundamental entity, and the subject-object as the fundamental relationship. The resulting humanism, thus set the task of determining its own basis—and therefore itself—can then proceed with its own destruction.

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EXCEPT YE UTTER BY THE TONGUE...

Concerning semantics and some of the so-called sociological articles in the MONTHLY during the past few years:

You snap on the radio: Fighting in Greece. Fighting in Palestine. Fighting in Burma. Fighting in Java. Fixing to fight elsewhere. A lady missionary—missionary, that is—from Boston keeping a Negro slave in California. No, not a lay lady from Atlanta keeping one in Mississippi.

Myths? What do you mean by myth?

Most scientists who do not carry Sunday-go-to-meeting divinity on one shoulder and Monday-go-to-lab "definity" on the other will agree with quite a bit of Dr. Read Bain's article, "Man, the Myth-Maker," in the July SCIENTIFIC MONTHLY. That is, as far as the good doctor of sociology is objective. But when therein he scintillates subjectively he may allow very little thinking left for man to do except as a post-Hoover ultrasociologist.

Take a word: for example, "integrate." When a mathematician says, "Integrate!" why you just go

ahead and integrate; even if you have to twist and squirm or have to fall back on Lebesgue and Stieltjes. But ofttimes in gobbledygookland, when one may be up a stump, one just beats one's breast with, or mumbles, "integrate." Let clinical controls and clean-cut definitions of terms go hang.

And with deep scientific humility I hope some altruist of relatively recent etymological leanings doesn't "implement" me with an "elementary audit of the mass media" which "stem" from the "content analysis" of "accurate summations of multi-million-word-and-image barrages." S'help us!

Shades of the refreshing clarity and pointedness and masterful simplicity of the language of, say, Thomas Huxley's "On a Piece of Chalk."

PAUL B. WILLIAMSON

New Orleans, La.

COPPER

The August issue of SM carried an interesting article by Professor Benjamin Moulton entitled "Copper Resources of the United States," with a series of charts that were most informative and certainly of general interest in view of the importance of the reserves of this metal to all our citizens. In the main I am in close agreement with Professor Moulton's summations, but I beg to take sharp issue with his review of the situation in Chile, where I resided during some eight years. Dr. Moulton states: "Other refineries are located in areas having ample amounts of available water power. Thus, there are refineries at Chuquicamata and Potrerillos, Chile, as well as at Tacoma, Wash., and Great Falls, Mont."

It seems a pity that a professor of geography should have made such a statement as this, for Chuquicamata is situated in one of the most absolute deserts in the world, where it is not only impossible to secure water for hydroelectric power but difficult and very costly to secure potable water for the townsite, to say nothing of the water that must be used to leach the ore and freshen the electrolyte in the electrolytic refining process. Fresh water must be piped in a distance of about fifty miles from the high cordillera to the mine and plant. As to power, this is developed at the coastal town of Tocopilla, using petroleum which, up to the war at least, was brought down from Mexico in tankers.

Chuquicamata is unique among all the copper mines of the world, not only that it is so much greater than anything of the kind in the United States, and that the ore is high-grade, but also that much of it occurs as a binder of copper sulfate in a sandstone matrix. Just as it would be impossible to mine nitrates in nearby saltpeter deposits if there were any rain to dissolve out the salts, so is it equally difficult to imagine that a mine of soluble copper salts could long resist such precipitation as would be necessary to supply water for hydroelectric purposes. The very fact of solubility of the ore makes it possible to by-pass the usual tedious steps that are necessary to carry the sulfides from the raw state up to the blister copper which is cast into anode bars for refining. Chuqui ores are merely leached with a solution of weak sulfuric acid, containing some copper sulfate to aid dissolution, since excess sulfate radicals in solution accelerate this step, the resulting liquors being the electrolyte, which may be treated directly in the refining tanks. Thus, the only output of copper is in a refined form that can readily be cast into wire bars for the electrical industry. In other words, it is easier to produce refined copper than any other kind of copper, which also explains the fact that Chuqui has shipped copper directly to Europe without additional beneficiation in the United States.

Much may be said for locating a refinery close to cheap water power. This justifies Professor Moulton's reference to Great Falls, Mont. However, Tacoma, for all its proximity to water power, was designed primarily to handle foreign ores that could be shipped in by water without paying transit charges through the Panama Canal. It is primarily a smelter rather than a refinery and handles too small a volume of electrolytic copper to compete with larger refineries in the East, which are equally near tidewater and enjoy proximity to the larger coal fields. Professor Moulton might have mentioned the large refinery of the Phelps Dodge Copper Corporation in El Paso, Texas, which is also distant from the copper manufacturing trade. This refinery is also distant from cheap water power and operates on natural gas from the Panhandle fields.

Other factors than water power also determine the location of a refinery. The Braden Copper Company, in Chile, another large copper producer, does not refine its product, even though its sources of cheap water power on the Río Cachapoal are virtually beyond computation. The reason is quite simple: the ores carry values in the precious metals entirely too meager to warrant labor costs of refining the blister electrolytically. Convertor copper, given a certain amount of fire refining, can be purified to a point where it is quite acceptable to the manufacturers of alloys and is still malleable enough to serve quite a number of other uses. Hence, Braden copper, too, can be shipped directly to Europe without preliminary treatment at refineries in the United States. With the two principal Chilean mines equipped to act independently of facilities in the

U. S. A., it is not strange that the principal imports into this country have been, in line with Professor Moulton's statement, in the form of untreated ores rather than pig copper; the quantity, also, up to the time of lifting the copper tariff, has, quite naturally, been correspondingly small.

P. R. GLEASON

Middle River, Md.

BACK INTO BALANCE WITH NATURE

As a faithful reader of the MONTHLY, I have now and then a desire to express an opinion. Not being a Ph.D., I scarcely aspire to contribute an article but might enjoy seeing what I offer in your published letters to the editor; as a matter of fact, these are usually more interesting than the articles, I find, being more uninhibited and less formal and pontifical.

What I wish to note is that, while I believe that our future welfare lies in the hands of scientists, this does not necessarily connote that we are to be saved by formulas and synthesizations, but rather because scientists face the sum total of proven facts and refuse to be dissuaded by any form of fancy or hysteria.

I am a humble worker at conservation: "soil-water-and-life-itself," as we speak of it amongst ourselves. After a decade of effort, I am fully convinced that we originally attacked "erosion" as the obvious ailment, whereas soil destruction and decline are merely symptoms of a deep social disturbance amounting to disease. Our job in the end is to preserve human life, and this will be done only by getting human life back into balance with nature and the rest of the life complex. We do find that the phenomena of human, vegetable, and animal life are inseparable and that the life complex is a vast symbiosis; soil seems to be the likewise inseparable foundation for the whole complex.

One way I think of the human problem is that our difficulties hinge on this gift of intelligence—or, perhaps better, articulate intelligence—which we alone seem to have: having it we must use it fully or it will destroy us. Nature is a vast and endless experimental laboratory, as is shown by what we call "evolution." In the slow course of time a great many species and genera and even forms of life have been discarded, and there is no reason to believe that man cannot deal himself out of the game unless he uses the talents that have been given him.

Intelligence would seem to have made obsolete the old game of a struggle for existence and the survival of the fittest, by making us aware of the possibilities of cooperation and symbiosis. This is why feudal individualism is being replaced by democracy, or at least efforts in that direction. Yet we still find that intelligence may only be maintained and advanced by the preservation of freedom for the individual. I do not argue in favor of any ritual or formal approach, but rather for complete use of intelligence and the irreducible minimum of inhibitions. I do believe that, if we all used our intelligence and faced the facts, our social problems would become negligible. Greed and urge for power over one's fellows are completely unintelligent. Humility is the primary attribute of intelligence.

What I should like to advocate is a much greater and more concerted effort toward coordinating all our knowledge with the whole Nature complex-making knowledge in vivo rather than in vitro, as I might paraphrase it—and a continuous effort toward simplification and lucidity in published dissertations. I remember what Sir Henry Deterding said some years back: that anything workable is simple and understandable by almost anyone, and that anything abstruse and complex might better be tossed into the wastebasket.

LAURENS C. BOLLES

Albuquerque, N. M.

ODE TO THE SCIENTIFIC MONTHLY

Oh, SCIENTIFIC MONTHLY, *sagacious publication,*
Full of facts and figures and precise information,
Edited by Campbell, of the A.A.A.S.,
And published every month at the Waverly Press,
Guided by the judgment of such eminent men
As Adams, Miles, and Mather, Robbins, Soule, and Flynn,
What chance have I, a medical neophyte,
Of writing for a journal so fully erudite?
What know I of radar or ornithology
Or spectroscopes or cyclotrons or cosmic astronomy?
And if I wrote of atoms or intricate molecule
I would only leave myself exposed to ridicule.
So how can this meager, embryonic M. D.
Get something published in THE SCIENTIFIC MONTHLY?
Unless it be these lines of wistful poetry.

EDWARD B. SINGLETON, M.D.

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Technological Notes

Important Scientific Instrument. Every school has its legends and traditions, including the sayings and behavior of some of the professors. The quotes most often handed down and longest remembered—by me, at least—are gentle plays on words and quizzical humor about the meanings of things said or written.

The reason I am thinking about this emphasis on expression, a trait more common in the older men than the younger, probably, is that I have just come across some releases which use the word "science" in a way I find slightly objectionable, though it is common enough in what passes for popular scientific speech and writing.

Professor Billy Evans, long the favorite lecturer on chemistry at Ohio State, was particular about definitions. "Science," he used to tell us, "is classified knowledge." We learned that science is information on which we may base a conclusion or action, but science itself—that vast fund of knowledge so often referred to with awe and reverence—would not itself be capable of action or decision.

And yet, falling into the habit of the popularizers, the National Geographic Society issued a release beginning "Nicaragua, current scene of a presidential shakeup, contains the only fresh-water lake known to science in which big salt-water fish abound." It is Lake Nicaragua, 100 miles long and 105 feet above sea level, and it contains sawfish, swordfish, and tarpon.

And General Electric, which should be more precise in its language, informed the papers last summer that "Science employs six main types of intricate machines to bombard the nucleus of the atom in an effort to make it give up its secrets." These are—might as well give the information while we are about it—the betatron, synchrotron, electrostatic accelerator, or Van de Graaf machine, cyclotron, synchrocyclotron, and linear accelerator.

In the room where Professor Evans used to do his lecturing on chemistry in particular and science in general is a quotation attributed to a colleague of his, now emeritus also, Professor C. W. Foulk: "The English language is the most important scientific instrument at your disposal. Learn to use it with precision."

That quotation is a good one for writers of releases and radio scripts, as well as for science popularizers and ad men. We all need to keep it in mind.

Dr. John Merrill Davis, president emeritus of Rio Grande College, gave me a gentle prod in the direction of exactness long ago when I was in the preparatory department of that little south Ohio school. I had done some typing for the doctor, and the bill, as I told him, was "about fifty cents." Saying I had charged him "about 49 cents," that was what he paid me.

Professor C. E. Sherman, who taught civil engineering in particular at Ohio State and English and life in general, once did some chuckling over a statement in a colleague's book on American history: "The battle of Point Pleasant was held October 10, 1774." Sherman sent the author a note and asked if invitations were sent out.

A legend about Professor Jimmy Boyd, of Ohio State's mechanics department, expresses it in a nutshell. "Young man," barked Jimmy, in the voice he had developed by teaching above the clatter of the machine shop, "you want to git all the English you can git."—M. W.

The Brownstone Tower

DURING the past three years in which I have written The Brownstone Tower I have shown to Dr. F. R. Moulton, our Administrative Secretary, the copy for nearly every issue before sending it to the printer. His approval was not required, but I wanted his advice, and he never failed me. Always he pointed out the rough spots in the copy and more than once he caused me to toss the copy in the wastebasket and rewrite it. I have never had a keener or a kinder critic. Dr. Moulton will not see this copy because I want to write about him in connection with the forthcoming Chicago meeting of the A.A.A.S.

In his seventy-sixth year Dr. Moulton will return this Christmas to the city in which he once shone like a supernova. He will return to Chicago as the administrative leader of the A.A.A.S., to which he has quietly devoted himself during the past eleven years. Only those who have worked with him, as I have, know how diligently he has toiled for the Association.

What has Dr. Moulton done for the Association? Let me mention a few of his personal contributions. He wrote the text of the *Proceedings* of the Association (1934–40), saw it through the press, and made it pay for itself. He wrote and delivered a long series of radio broadcasts on science. He initiated the "Symposium Volumes" of the Association—one of his most important services to science and the Association. He selected symposia worthy of publication in book form, edited hundreds of manuscripts for the preparation of more than twenty volumes, made arrangements for their production and sale, and came out in the black.

Because *Science* did not reach all members of the Association, Dr. Moulton initiated the eight-page *A.A.A.S. Bulletin* in March 1942. It appeared every month until December 1946, when it was temporarily discontinued. Through the *Bulletin* all members of the Association received information about the A.A.A.S. and its affiliated societies. Dr. Moulton wrote most of the copy for each issue, and his meaty editorials, each one skillfully written, were widely appreciated.

As long as the SM needed his editorial help, Dr. Moulton gave much of his time to it. He was a coeditor of the SM from 1939 to 1943. Many contributions from him are to be found in it. He engineered the difficult task of transferring the operation of the SM and of *Science* from the Cattells to the A.A.A.S. in Washington. To house the editorial and business offices of the Association under one roof, it was necessary to leave the Smithsonian Institution. Dr. Moulton set in motion a building fund campaign, and with the money so obtained, plus the savings resulting from his economical operation of the Association, our present building and our future building site were purchased.

I hope these few words will prompt our readers to realize that they have a devoted, farseeing, and courageous Secretary. He should be honored in Chicago where, at The University of Chicago, he gained scientific renown in celestial mechanics from 1896 to 1926. Never afraid of doing the unusual, he resigned from the University in 1926 and remained in Chicago for eleven years as an officer of Utilities Power & Light Corporation. During that time he continued to write scientific books and performed a remarkable public service during the depression as the Director of Concessions of the Century of Progress International Exposition. In opening the fair he hitched it to a star, Arcturus. But his feet were, and still are, on the ground.

F. L. CAMPBELL

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The response to the first contest, which closed on November 1, 1946, was very grat fying. The first prize was won by Clyde Kluckhohn, Department of Anthropology, Harvard University, for his manuscript, *Anthropology and the World Today*. From a total of 250 entries, nine manuscripts were accepted for publication—six by Whittlesey House and three by the College Department of the McGraw-Hill Book Company.

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New Books Received

Duncan of Liverpool. W. M. FRAZER. 163 pp. Illus. 8*s*. 6*d*. Hamish Hamilton. London. 1947.

Measuring Business Cycles. ARTHUR F. BURNS and WESLEY C. MITCHELL. xxvii + 560 pp. Illus. $5.00. Nat. Bur. of Economic Research. New York. 1946.

The Theory of Social and Economic Organization. MAX WEBER. A. M. HENDERSON and TALCOTT PARSONS, Translators. x + 436 pp. $6.00. Oxford. New York. 1947.

Outlines of the Geography, Life, and Customs of Newfoundland—Labrador. V. TANNER. 2 vols. 909 pp. Illus. $13.50. Cambridge Univ. Cambridge, Eng. Macmillan. New York. 1947.

Overcoming Stammering. CHARLES PELLMAN. 160 pp. $3.00. Beechhurst Press. New York. 1947.

Chippewa Village. W. VERNON KINIETZ. 259 pp. Illus. $3.00. Cranbrook Inst. Bull. 25. Bloomfield Hills, Mich. 1947.

One two three . . . infinity. GEORGE GAMOW. xi + 340 pp. Illus. $4.75. Viking. New York. 1947.

Test Yourself. WILLIAM BERNARD and JULES LEOPOLD. 94 pp. Illus. $2.00. Hellman, Williams. New York. 1947.

The Arboretums and Botanical Gardens of North America. DONALD WYMAN. 104 pp. Illus. $1.50. Chronica Botanica. Waltham, Mass. Stechert-Hafner. New York. 1947.

Personality. GARDNER MURPHY. xii + 999 pp. $7.50. Harper. New York. 1947.

New Weapons for Air Warfare. JOSEPH C. BOYCE, Ed. xviii + 292 pp. Illus. $4.00. Little, Brown. Boston. 1947.

Combat Scientists. LINCOLN R. THIESMEYER and JOHN E. BURCHARD. ALAN T. WATERMAN, Ed. xiii + 412 pp. Illus. $5.00. Little, Brown. Boston. 1947.

A Multitude of Living Things. LORUS J. and MARGERY J. MILNE. 278 pp. Illus. $4.00. Dodd, Mead. New York. 1947.

The Genus Crepis. Part I. *The Taxonomy, Phylogeny, Distribution, and Evolution of Crepis*. ERNEST BROWN BABCOCK. xii + 198 pp. Illus. $3.50, paper; $4.00, cloth. Part II. *Systematic Treatment*. ERNEST BROWN BABCOCK. x + 832 pp. Illus. $10.00, paper; $12.00, cloth. Both volumes: $13.50, paper; $15.00, cloth. Univ. of Calif. Berkeley and Los Angeles. 1947.

Small Wonder. GESSNER G. HAWLEY. ix + 220 + x pp. Illus. $3.50. Knopf. New York. 1947.

Naturforskeren Johannes Schmidt. ØJVIND WINGE and Å. VEDEL TÅNING, Eds. 187 pp. Illus. Kr. 12.75. Gyldendalske Boghandel. Copenhagen. 1947.

The Hybrid-Corn Makers, Prophets of Plenty. A. RICHARD CRABB. ix + 199 pp. Rutgers. New Brunswick, N. J. 1947.

Very Soon Now, Joe. ALAN MCCRACKEN. 186 pp. $3.00. Hobson. New York. 1947.

Louis Agassiz, Scientist and Teacher. JAMES DAVID TELLER. xi + 145 pp. Ohio State. Columbus. 1947.

Theory and Applications of Electricity and Magnetism. CHARLES A. CULVER. vii + 594 pp. Illus. $5.00. McGraw-Hill. New York and London. 1947.

East of the Andes and West of Nowhere. NANCY BELL BATES. 237 pp. Illus. $3.50. Scribner's. New York. 1947.

Nothing So Strange. JAMES HILTON. 308 pp. $2.75. Little, Brown. Boston. 1947.

The Metropolitan Life. MARQUIS JAMES. vii + 480 pp. Illus. $5.00. Viking. New York. 1947.

Meals for Millions. Final Report of the New York State Joint Legislative Committee on Nutrition. 213 pp. Illus. Free. Albany. 1947.

Sunspots in Action. HARLAN TRUE STETSON. ix + 252 pp. Illus. $3.50. Ronald Press. New York. 1947.

Reading and Visual Fatigue. LEONARD CARMICHAEL and WALTER F. DEARBORN. xiv + 483 pp. Illus. $5.00. Houghton Mifflin. New York. 1947.

Genetics is Easy. PHILIP GOLDSTEIN. 72 pp. Illus. 75 cents. Garlan Pub. Hoboken, N. J. 1947.

Our Flowering World. RUTHERFORD PLATT. vii + 278 pp. Illus. $6.00. Dodd, Mead. New York. 1947.

Traffic Survey of Alexandria Metropolitan Area. Louisiana Department of Highways and Local Governmental Units, in cooperation with U. S. Public Roads Administration. 107 pp. Illus. Baton Rouge. 1947.

Calcium and Phosphorus in Foods and Nutrition. HENRY C. SHERMAN. vi + 176 pp. Illus. $2.75. Columbia Univ. New York. 1947.

Nutrition in Relation to Cancer. ROY WALDO MINER, Ed. 140 pp. Illus. $2.00. Annals of the New York Academy of Sciences. Vol. 49, Art. 1. 1947.

The Indians of the Americas. JOHN COLLIER. xi + 326 pp. Illus. $3.75. Norton. New York. 1947.

Maya Explorer. VICTOR WOLFGANG VON HAGEN. xviii + 324 pp. Illus. $5.00. Univ. of Okla. Norman. 1947.

Frank J. Sprague and the Edison Myth. HARRIET SPRAGUE. 24 pp. $1.00. William-Frederick Press. New York. 1947.

Laboratory Handbook for General Chemistry. ROLAND M. WHITTAKER and ALEXANDER P. MARION. v + 363 pp. Illus. $3.50. Remsen. Brooklyn. 1947.

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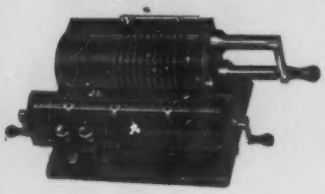

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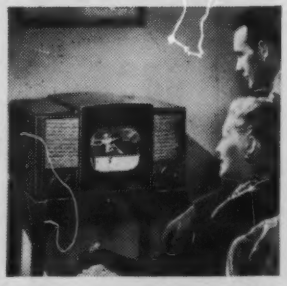

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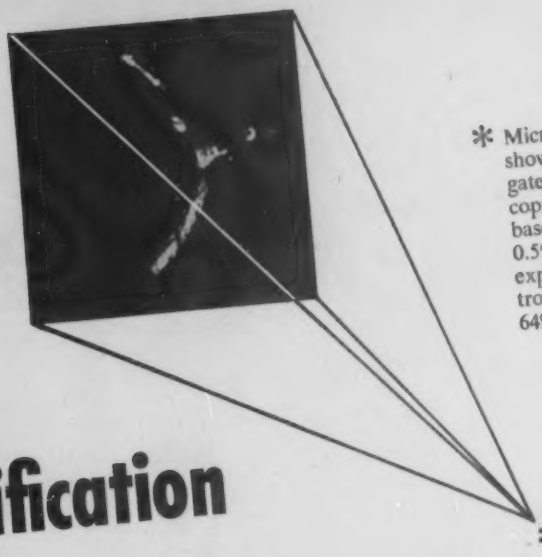

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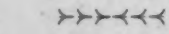

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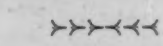

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